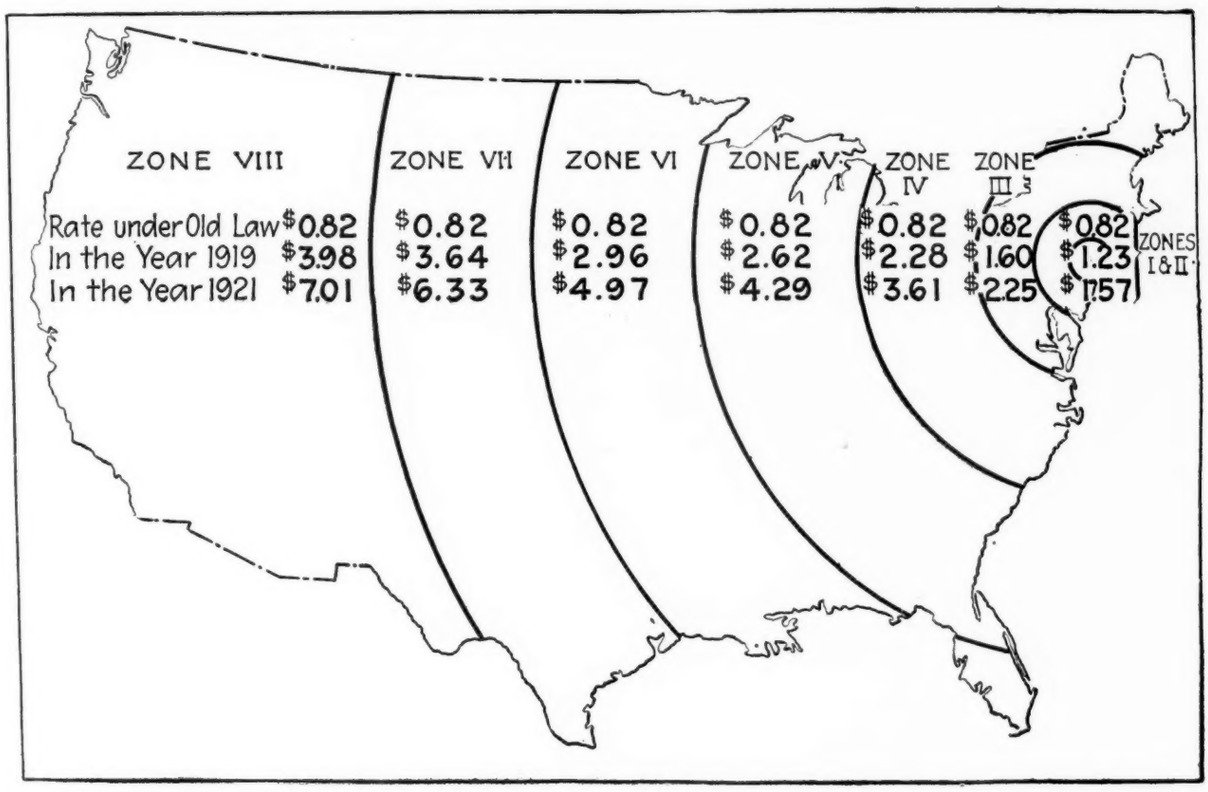
POWER

Volume 49 New York, June 10, 1919 *Number* 23

Where Do You Live?

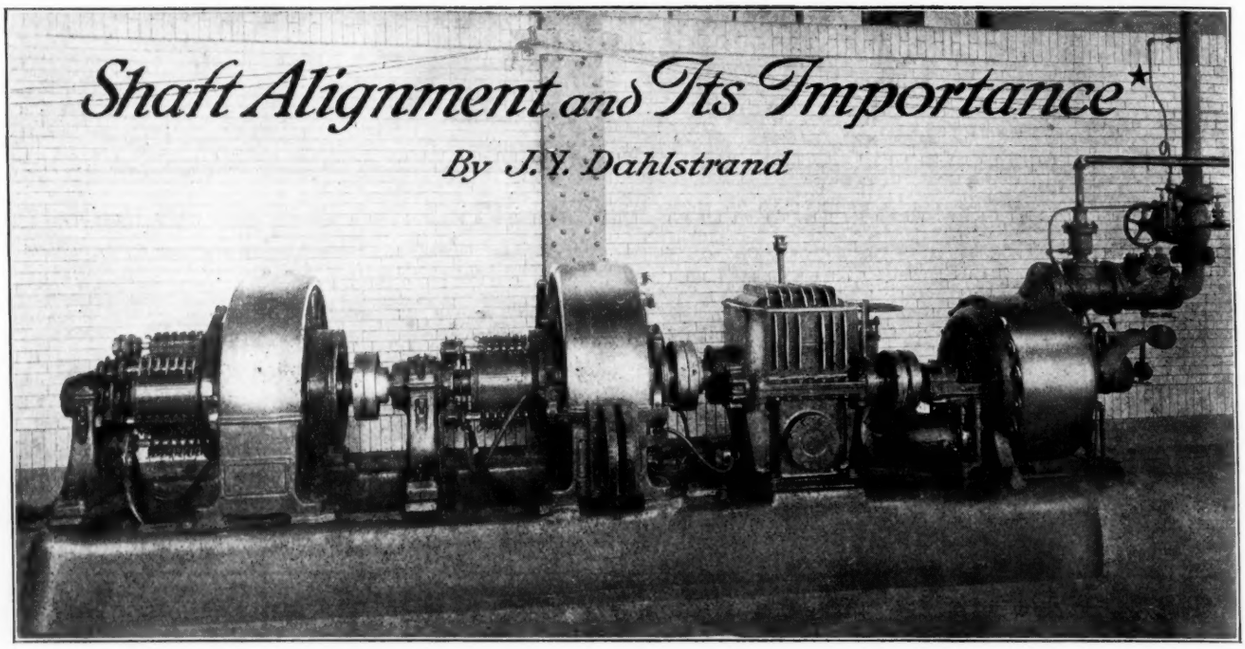
This Map shows the zones created by the Postal Zone Law and the postage to be paid on your copy of Power.


ZONE VIII
ZONE VII
ZONE VI
ZONE V
ZONE IV
ZONE III
ZONES I & II
Rate under Old Law $0.82 $0.82 $0.82 $0.82 $0.82 $0.82 $0.82
In the Year 1919 $3.98 $3.64 $2.96 $2.62 $2.28 $1.60 $1.23
In the Year 1921 $7.01 $6.33 $4.97 $4.29 $3.61 $2.25 $1.57

NOTE—For the year 1918 we paid the penalty postage. For the year 1919 we are billing our subscribers who live west of the Mississippi $1 extra to cover a part of the Zone Postage. There will be another increase in postage in 1920 and still another in 1921. (See Map.) If the Zone law is not repealed, we shall be compelled to readjust our subscription price so that the Subscriber will pay according to the Zone in which he lives.

Prior to this Zone Law all citizens had equal rights.
Why should not these rights be restored?

Ask your Congressman!



Shaft Alignment and Its Importance*

By J. Y. Dahlstrand

Reasons are presented as to why two or more members of a unit mounted on the same bedplate lose their alignment. This can occur during the shop test or when the unit is placed in position in the plant. Uneven strain on the anchor bolts, incorrect foundation, improper and insecure doweling and wearing are causes for misalignment.

IF IN THE operation of small and medium-sized rotating machinery—pumps, generators, motors, blowers or turbines—the various difficulties that come up such as trouble with bearings, shafts and packings, were recorded and traced to their origin, it is likely that 60 per cent. of them would be found to be the direct or indirect result of bad shaft alignment. The question of alignment is so old and appears so simple of solution to the average power-plant engineer, that in the majority of cases he ascribes other conditions as causes of the difficulties encountered.

In spite of all that has been said and written on this subject, the alignment of rotating machinery in the average power plant is far from what it should be to insure long life and trouble-proof operation, which condition, after all, in the majority of cases can be obtained with small effort and retained at low expense.

The results under given inferior conditions of alignment do not vary greatly, except that they become more complex and far-reaching the longer such conditions exist. These results are vibration, burned-out bearings, bent shafts, crystallization of material in the revolving elements, resulting in breakage of shafts, couplings and other rotating parts—and this often where the stresses in these parts appear practically negligible.

It should be noted that under such conditions of shaft alignment some kinds of machinery do not exhibit the results with the same rapidity as others. As a general rule machines operating at lower speeds—below 2000 r.p.m.—stand up in service longer under the foregoing conditions than do higher-speed machines. From this, as well as some other causes, has come the conception that machinery having operating speeds of 4000 r.p.m. and up is more unsatisfactory than machinery operating at speeds lower than 4000 r.p.m., a conception that undoubtedly has good foundation if considered from certain standpoints. As the result of the higher stresses and surface speeds high-speed machines require correct static and dynamic balance, correct alignment and the best of lubrication. In many cases the cost of providing these conditions more than offsets the actual gain in economy and first cost of the high-speed machine.

Assuming that the foregoing statements concerning conditions as to alignment of units in the average power plant are in accordance with the facts, let us investigate the causes and reasons for the existence of these conditions. In the writer's opinion there are two popular misconceptions which are more responsible than anything else and are as follows:

The couplings generally used to transmit the power from the driving member of the unit to the driven have been termed flexible couplings. This name is correct in so far as it refers to movement in axial direction, but is not to be construed to mean that this type of coupling will permit of any appreciable error in alignment. Contrary to common supposition, no coupling has yet been devised, as far as I know—and is not likely to be—which will compensate for any such error.

When two or more members of a unit are mounted on a common baseplate, lined up correctly in the manufacturer's plant and then removed to be installed in the customer's plant, it is common that too much reliance is placed on the baseplate to keep the unit in line. This is wrong. A baseplate, even if it is high and massive, is a flexible object. It is unsafe to rely on any baseplate alone to keep a unit in line.

If all the members of the unit are mounted on a common baseplate when leaving the manufacturer's plant, it is safe to say that while in test the unit was in line. However, there is no certainty that the baseplate was not sprung at the time of testing. It does not require a very great force to spring a baseplate of a reasonable section out of shape. Furthermore, it is almost im-

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possible to avoid this, which is clear when it is considered that the baseplate is ordinarily bolted down by using fairly good-sized bolts, and the workman does not have to apply a very great force on his wrench to bring about a force in the direction of the bolt which is considerable. A unit mounted on a baseplate such as this, whether actually sprung in test or not, when finally placed on its foundation will have to have its baseplate brought back into the condition that it had while testing in order to be in line. If this is not done, a change in the doweling between the baseplate and the various members mounted upon it must be made.

It is not uncommon to find that a customer receives a unit—say a turbine and a generator of small capacity, 10 to 50 kw., mounted on a small baseplate—and will place this set on a common floor or some other foundation that appears to be reasonably smooth, tighten it with holding-down bolts and expect the unit to be in line. It is purely accidental if the machine is actually in line. It is not uncommon that the alignment varies as much as $\frac{1}{16}$ in., even with relatively heavy bases under them, and mounted on apparently smooth foundations.

Units may have been erected and lined up perfectly, but may have developed misalignment. One common cause of this is that the foundation is not made correctly. Foundations under units should be sufficiently rigid to maintain the alignment of the unit. Solid concrete foundations are preferred to the hollow construction, as the latter have a tendency to furnish sounding boards where vibrations are set up and intensified. Also the rigidity of a solid foundation is generally better. Concrete foundations ought never to be tied to the foundations of a building. For certain units steel foundations are satisfactory, provided they are made with the rigidity particularly in view. No unit, even if small in size, should be placed directly on a wooden floor, unless this floor is very heavy and has been installed long enough to be thoroughly seasoned. Only small units should be placed in this manner.

It is always more satisfactory to set the unit on a

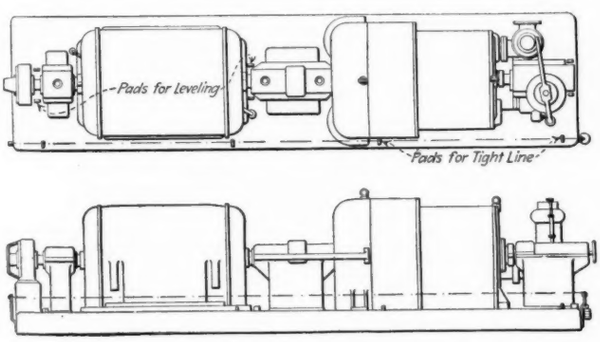


FIG. 1. TURBO-GENERATOR UNIT ON COMMON BASEPLATE.

slab of concrete, from 8 to 10 in. thick, poured directly on the floor and reinforced with steel rods or expanded metal embedded in the concrete 1½ in. above the bottom surface and the same distance below the top surface of the slab.

After a unit has been placed on its foundation in proper alignment, using steel wedges inserted at various points under the baseplate and anchoring the baseplate to the foundation by means of holding-down bolts, the baseplate should be grouted to the foundation to provide bearing along its entire lower surface.

In some cases units are shipped out with the various members mounted on different baseplates, to be set on the same foundation. This is found to be satisfactory, but will require a certain amount of additional work in erecting.

Improper and insecure doweling of the members of the unit to the baseplate is another cause for change in alignment after the unit has been erected. Still another is wear of bearings. Foremost among other causes tending to change alignment are pipes or stays attached to the unit without proper supports. Steam

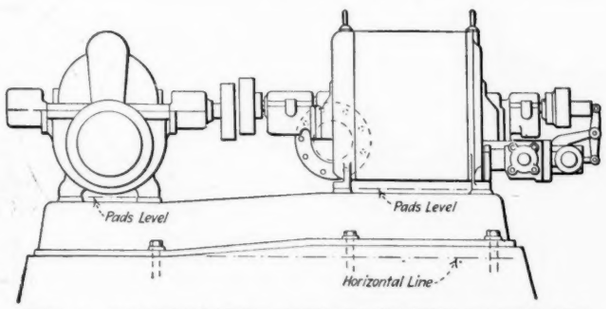


FIG. 2. EXAGGERATED CASE OF SPRUNG BASEPLATE

and exhaust lines on steam turbines are particularly referred to. These pipes must be supported and provided with expansion joints so as to relieve the turbine of strains due to weight, expansion or unbalanced pressure. If this is not done, the casing of the turbine may be so distorted as to cause serious misalignment.

Some manufacturers have adopted a method to secure proper alignment in the field when erecting, with a minimum amount of difficulty, as follows:

Fig. 1 illustrates a steam turbine coupled to an alternating-current generator and mounted on a common baseplate. This unit is to be tested at the factory, after which it is shipped out to be installed in the customer's plant. It is desired that the same conditions of alignment that the unit had in test be reproduced. If the individual parts, the pedestals and frames, are doweled to the base in the proper manner, the alignment sideways will be taken care of if the unit is placed in the same position of level (to be checked at various points) as it had in the factory, in a direction at right angles to the center line of the unit. However, as baseplates, no matter what thickness, are always in some degree flexible, the original alignment in the vertical plane cannot be reproduced so readily. It is never safe to use levels to prove this alignment as the baseplate may be sprung, as indicated in an exaggerated manner in Fig. 2.

To facilitate the alignment in the vertical plane, there are provided on top of the baseplate certain leveling spots, or measuring points, which are filed and scraped at the time the unit is being tested, with all parts mounted on the baseplate and in alignment. The procedure is as follows:

The base should be placed in position, with all its pads in as good level as possible, using an ordinary 8- or 12-in. level. The reason for the expression "in as good level as possible" is as follows: It is never possible to plane a baseplate so that the surface of its pads will be absolutely parallel, because a baseplate is flexible and when bolted to the planer it will always be sprung one way or the other. To the layman this statement sounds strange, but it is nevertheless a fact. The amount the pads will be out of parallel varies, of course,

with the size and length of the baseplate as well as with its rigidity, but it is not uncommon even with the best of men doing the work to have the pads nonparallel a considerable amount after the baseplate is removed from the plane of the table. The expression as used is supposed to denote that the baseplate should be so placed that the angle the pads at the two ends of the baseplate are inclined toward each other will be approximately divided in two by a horizontal line. All

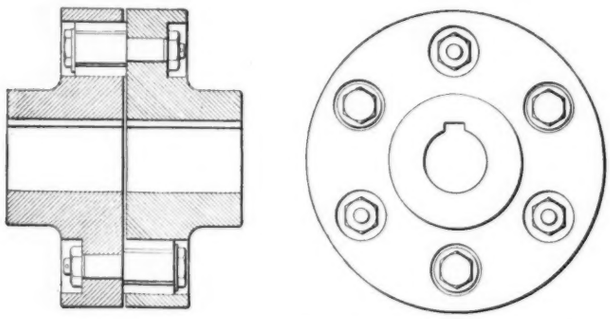


FIG. 3. PIN-TYPE COUPLING

parts, pedestals and frames should then be assembled on the base and the coupling lined up accordingly. Later, certain methods used in aligning shafts will be illustrated.

A tight line of about 0.017-in. piano wire should be strung along one side of the base, extending if possible the length of the unit, directly over a number of ½ x 1-in. pads (purposely made small to allow easy filing and scraping) on the base provided for measuring purposes, one of these pads near each end of the wire and others between. The wire should be held tight with a 30-lb. weight at one end. The distances to the small pads from the wire should then be measured, and the spots under the wire to which the measuring was made should be stamped with an *O*, the measuring in the field to be done to the center of this *O*, and the distance to the wire should be stamped alongside this same *O*, in thousandths of an inch.

For obvious reasons it is desirable to keep the distance to the wire an even number of inches, and if the base has the same height throughout it is desirable to keep the distance to the wire exactly the same on account of the sag in the wire as well as minor inequalities in the planing of the pads. This will invariably mean that some of the pads will have to be filed or scraped down a few thousands of an inch. Even though the distance to the wire is an even number of inches, the figures should be stamped in decimals to indicate that the distance is correct within a thousandth of an inch.

The leveling across the baseplate may be done both in the shop and in the field with an ordinary 12-in. level. Separate pads, 1½ x 1 in., are provided on the base for this purpose. These pads should be filed or scraped down until they are in level when erecting in the shop.

All the foregoing is to be done during the test of the machine, while the various parts are mounted on the baseplate and are in alignment.

Incidentally, it might be well to warn against checking the level of the pads with an ordinary instrument without turning this end for end, as the glass is not always parallel with the bottom surface of the level. Also, it is never safe to check from one end of the bubble only. The reason for this is that the expansion of the liquid changes the size of the bubble. If the level was determined by noting which division one end of the bubble reached, it might easily be possible to make an error of several thousandths of an inch in a 12-in. length.

Later, this unit is shipped to the customer's plant, sometimes taken down, sometimes shipped in the condition in which it was tested. In either case, when put on the foundation in the customer's plant, a similar tight wire should be strung across the pads in an axial direction, using an equal weight, and the same dimensions reproduced as were obtained in the factory by putting wedges under the baseplate. Also the alignment across the baseplate should be checked in a similar manner. It is unnecessary to say that the machine should also be placed as nearly level as possible in an axial direction. This, however, is not as important as it is that it be placed correctly in line; in fact, certain builders of the Parson type of turbine incline their shafts a considerable amount for certain reasons in connection with the functions of the balance pistons on the turbines.

The couplings between the members of the unit—in order to be successful in operation—should allow free end movement of the two shafts without imposing undue strains or stresses on any of its parts or creating any end thrust on the ends of the shafts. They should have no loose parts and should be as free from wear and lost motion as possible. If not inclosed in housings, they should have no projecting parts to cause undue windage and noise, and which would be unsafe because of the possibility of catching in workmen's clothing.

Two types of couplings are commonly used. The pin type in its most common form is illustrated in Fig. 3. It consists of two semi-steel or forged steel flanges, in which are inserted steel pins secured with nuts, washers and cotters in one coupling half and carrying on the opposite end rubber bushings, brass-lined on the inside and with outside bearing on the inner face of

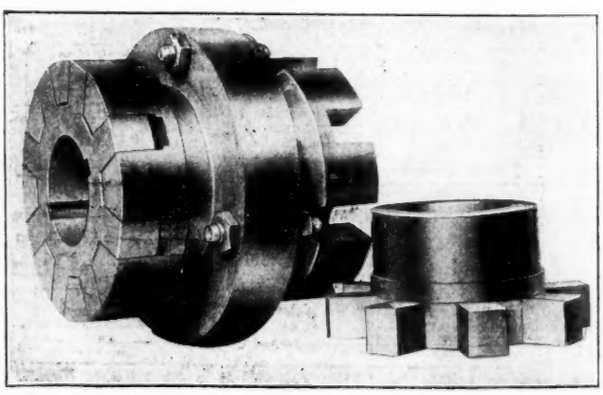


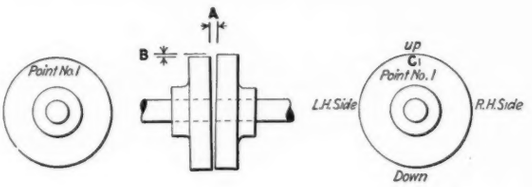
FIG. 4. CLAW-TYPE COUPLING

the bored-out holes in the other coupling half. The holes for the pins are bored out accurately with each other and so as to be parallel with the bore through which the shaft passes.

There are various other constructions of this type of coupling. Sometimes the rubber bushings are substituted with bronze bushings and lubrication is provided for the bushings and steel pins. In such cases it is naturally necessary to inclose the coupling. This latter type will allow for even a smaller variation in shaft alignment than will the rubber-bushing type.

Either one will not operate successfully unless the shaft alignment is within seven or eight thousandths of an inch.

In the claw type of coupling, Fig. 4, each half consists of two parts: The inner one, or sleeve, keyed to the shaft and provided on the outer flange with claws; and the outer one, which has two flanges and is provided with a set of claws in one of these flanges. These fit into the spaces between the claws on the fixed sleeve.



Important Note:
The two Shafts must always be turned over together while measuring so that point No.1 on each of the Couplings always are Opposite each other

STANDARD TABLE OF DIMENSIONS TO BE OBTAINED EACH TIME ALIGNMENT BETWEEN TWO SHAFTS IS CHECKED

Distance "A" at Point No.1 for Both Shafts turned Over Together to Varying Positions		Distance "B" at Point No.1 for Both Shafts Turned Over Together to Varying Positions	
UP	0.124	UP	0.008
R.H. SIDE	0.124	R.H. SIDE	0.008
DOWN	0.124	DOWN	0.008
L.H. SIDE	0.124	L.H. SIDE	0.008

The Above Indicates that Shafts are Parallel and in Line. If Dimensions not Constant for Each Position they Should be made so by Shifting or Shimming Under Feet of One of the Numbers

FIG. 5. DATA FOR ALIGNING COUPLINGS

The two shafts are connected to each other by bolting the outer sleeves by means of the plain flanges. This type of coupling should preferably be lubricated, as otherwise wear is liable to take place. Even though from this construction one might suppose that it would be capable of taking care of considerable misalignment, this is not correct. This coupling will not operate satisfactorily unless the alignment comes inside the figures mentioned for the first type of coupling. The claw type of coupling must be inclosed. It is used in preference to the pin type to transmit higher horsepowers and to save space and weight.

The methods used for checking the alignment of the shafts, whether the one type of coupling is used or the other, are numerous. Perhaps the most accurate is the one where a steel line is used. In order to check the alignment of the unit using a steel line, it is necessary to remove the upper half and rotor of the unit. The lower half of the bearings, however, will be left in place. The steel wire is then stretched from one outer bearing to the other, exactly in the center of the bearings, due allowance having been made for the fact that the journal has a certain clearance in the bearing. The alignment of the intermediate points is prefected in accordance with this wire after corrections have been made for the sag in the wire, which will vary, according to the size of the wire, the span and the weight stretching it. This sag may be calculated from the following formula:

$$D = \frac{WL^3}{8X}$$

Where

W = Weight in pounds per inch diameter of wire; L = length of span in inches; D = deflection in inches; X = weight in pounds of weight applied.

Another method, which is more common because more convenient, is that of checking the alignment by the coupling faces and diameters. This does not require any dismantling of the unit, but simply the removal of any guard that may be present outside the coupling. It can be done by anyone who is in possession of a set of "feelers," or thickness gages, and an ordinary steel scale. The approximate procedure to be carried out is as follows:

Two shafts may suffer from two kinds of misalignment. They may be out of line sideways (in other words, the ends of their axes may not meet) or they may be nonparallel. It is always possible to check the alignment of two shafts from the two coupling halves even though these halves do not have their faces perpendicular to the axes nor their outside circumference concentric with the shafts.

There are two requirements to be fulfilled in order that the shafts should be in line. The first one is that the distance A, Fig. 5, between the coupling halves should be the same whether this point is up, on the right-hand side, down or on the left-hand side, when the two shafts are turned at the same time when measuring this dimension. A convenient way of doing this for the pin-type coupling, is to insert the coupling pin, without bushing, through both halves of the coupling and leave this in while measuring. It is necessary that the two shafts, while taking this measurement, be pushed as far apart as the thrust bearings will allow them to go, in order to avoid errors in measurements due to end movement of the shafts.

In the second place it is necessary that the dimension B at the point 1, as indicated in Fig. 5, should be the same no matter whether this point is up, on the right-hand side, down or on the left-hand side. It is important to remember that when taking this measurement both shafts should be revolved together.

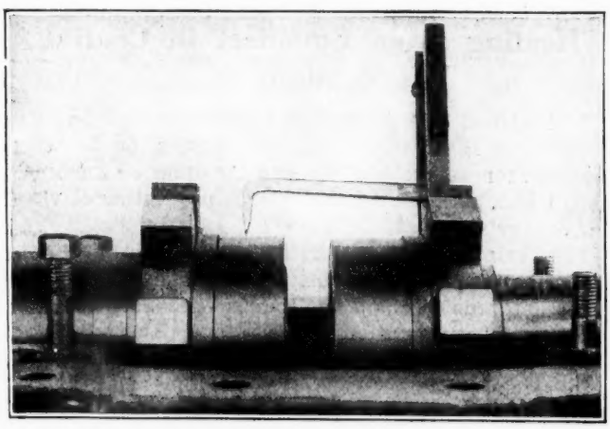


FIG. 6. METHOD OF CHECKING ALIGNMENT

The table in Fig. 5 shows all the dimensions which it is necessary to find on the coupling in order to determine the alignment both as far as being parallel and and as far as both axes meeting each other are concerned. A table of this kind should be made up each time it is desired that the alignment of a machine be checked.

In literature and instruction books on the subject of alignment one will always find that customers and en-

gineers are asked to try to bring the faces of the two couplings parallel to each other. This is not entirely safe, as in some cases, while the coupling bolts will be parallel to the bore of the coupling half, the faces are not necessarily perpendicular to the shaft. If the amount which they are out is small, this fact is not necessarily an indication of poor workmanship and will make no difference in the operation of the machine. However, they should naturally come as close to being perpendicular as possible.

The foregoing method, however, avoids errors due to incorrect machine work. The alignment of the shafts may be checked no matter what the condition of the couplings may be. For this reason the writer considers the foregoing method more satisfactory.

It is highly desirable that the alignment of all units, whether small or large, in power plants be checked at certain intervals to see that the machinery is kept in line, and it is recommended that the method just outlined for the pin-type coupling be used in doing this as it is a quicker and more convenient method, in the majority of cases requiring only four or five minutes, and may save great inconvenience and expense.

The method generally used for checking the alignment when the claw-type coupling is used is approximately the same. Fig. 6 shows this type of coupling with a test rod inserted. The distance between the sleeve and the end of this rod is checked with a thickness gage in the same manner as the distance *B*, Fig. 5, was checked in the pin-type coupling. In all cases the two shafts should be rotated together. The distance between two claws directly opposite each other should be measured in the same manner as distance *A*, Fig. 5, was measured. In order that the shafts should be in line, these two distances should be the same no matter whether the points measured are up, on the right-hand side, down or on the left-hand side.

Heating as an Equalizer in Central Stations

In 1911 and 1912 M. A. Beaurrienne presented to the Société des Ingénieurs Civils two studies, one on city heating from central stations and the other on combinations which permit the simultaneous production of electric energy and heat.

The variations in consumption of steam in a station are an obstacle to its economic reproduction. In order to regulate this consumption, the heat produced between the peaks of consumption may be accumulated in reservoirs of hot water, this heat to be utilized afterward in industrial processes, lavatories, washing and heating.

These reservoirs are fed through automatic valves which open when the steam pressure in the system goes above a predetermined point, and their efficiency, when well insulated, is superior to 95 per cent., even when the mass of water is left without giving up or receiving heat during twelve hours.

If a station should have a maximum production of ten tons, for example, six generating units would be installed, so that they could each produce two tons. Five of these units would be sufficient to assure the total production, and the sixth would serve for the recharge. One would put into service a greater or less number, so that each would function always under the conditions corresponding to its most economical service.

Using automatic stokers, the thickness of the fire bed, the rate of feeding, etc., can be regulated for the entire period, and the boilers run at a uniform rate, which will conduce to a better efficiency. The necessary attention of the fireman, not always the most economical, will also be reduced.

Monsieur Beaurrienne then considers the transportation of the heat by different means, air, hot water and steam at high or low pressure, and shows that in most cases the transportation by hot water is the most simple and economical.

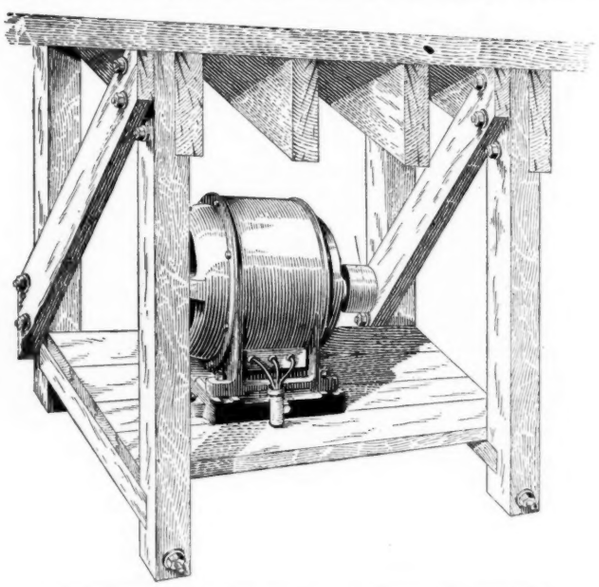
For the heating of industrial buildings and workrooms of considerable height, the circulation of heated air is preferable to the employment of suspended pipes. If the fans or blowers by which the air is circulated are run by engines the exhaust of which can be absorbed by the heat accumulated, the fuel consumption for such purpose will be negligible.

Monsieur Beaurrienne considers the general distribution of heat in a city, steam for industrial usages being furnished by the boilers of the central station, and that for heating by the exhaust steam of the central stations' prime movers. This combination not only would permit the reduction of the weight of steam used, but would result in a better performance of the boilers under a uniform load.

Overhead Wooden Platform for Motors*

By L. M. Harrison

When floor space is at a premium, it may be desirable to mount electric motors on platforms suspended from ceilings instead of supporting them on the floor. In the illustration are shown the details of a satisfactory support for motors of capacities up to 30 hp. Four 4-



STRUCTURAL DETAILS OF MOTOR PLATFORM

x 6-in. timbers bolted to the floor joists sustain the platform floor. To these vertical pieces are clamped two 3- x 4-in. cross-timbers which act as beams to which the 2-in. tongue-and-groove flooring is spiked. Two 1-in. tie-rods bind together the lower ends of the vertical supports. Where the side pull is great, to insure against shifting, diagonal braces, as shown, may be used to prevent lateral displacement.

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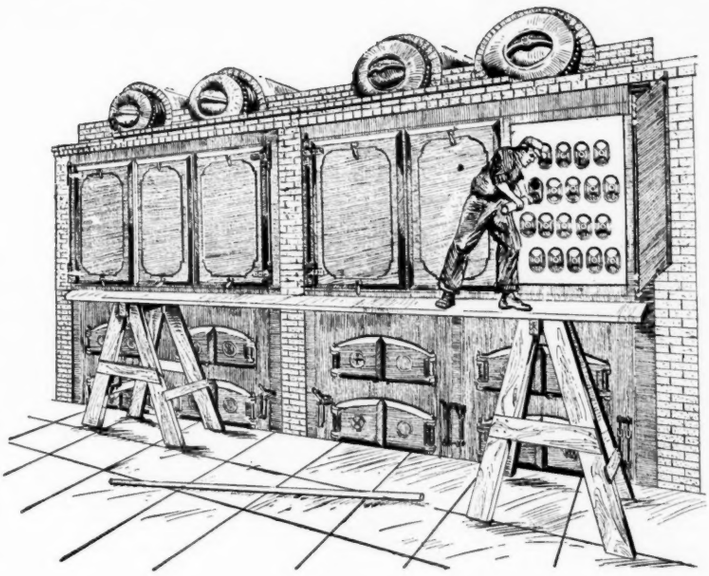
Boiler-Tube Failures

By WALDO WEAVER



ONE may well wonder why there are so many boiler-tube failures when so much is being said and done toward economy and the "safety first" movement. A few years ago it was a common thing to go into a plant and be told that some of the boilers had not been turbined for a matter of nine months or a year. On one occasion I was amused when a fireman said to me, "We call these two boilers on this side the summer boilers and those on that side the winter boilers." They ran two boilers during the summer and cleaned the other two ready for winter; then during the winter they cleaned the other two boilers and got them ready for the next summer.

Most of the tube failures in horizontal water-tube boilers are caused by the accumulation of sludge and scale, which may be very thin and light, in the two bottom rows of tubes directly over the fire. This sludge is held in suspension while the boiler is steaming rapidly, but when the fire is deadened it will invariably stop in mass and accumulate in little piles in the bottom tubes, generally toward the first baffle in vertically baffled boilers. Naturally, this will cause the tubes to burn when the fire is brought up quickly. It has been thoroughly demonstrated that running a boiler to 275 per cent. capacity will not burn the tubes if they are clean, free from oil and the baffling and arches are correct.

There is one way to prevent the loss of tubes in a horizontal water-tube boiler, and that is to turbine the two bottom rows every time the water is changed. Another valuable thing to remember is—Do not use a feed-water treatment that will cause the scale to break loose, thus giving it an opportunity to circulate with the water and eventually to accumulate in the bottom rows of the tubes and burn them.

Some years ago I told what good results had been achieved through the use of graphite as a scale remover. However, I afterward discovered that I was losing a lot of tubes because the graphite would loosen the scale in the drums and headers and it would then lodge in the bottom rows, as previously explained. Substituting a feed-water treatment compounded to suit the water and having a caustic base practically eliminated this loss of tubes.

I had a similar experience in another plant after using a noncaustic boiler compound which, it was claimed, would put a coating on the tubes, etc., making it impossible for scale to adhere to the surfaces. The loss of tubes in this case was enormous, running as high as 9 to 11 tubes per month per boiler, whereas before using the "dope" we seldom lost more than one tube per boiler in six weeks. Needless to say, I quickly discontinued the use of this stuff and had the water analyzed and purchased a treatment having a caustic basis. After doing this, our tube loss returned to normal and eventually we forgot we had any tubes in our boilers.

River and canal water will usually cause a great loss of tubes due to the presence of sewage, mud and chemicals from manufacturing plants. I have found this to be true in three plants in different parts of the United States. Changing to well or spring water stopped the trouble in all three cases notwithstanding the river water was lower in solids than the well water.

Engineers do not attach enough importance to oil in the feed water as condensate. Some years ago I witnessed a sad experience with a small boiler; tubes were lost every week, also some headers. Frequently, the boilermakers would not get back to the shop before they would be recalled. It seemed like a mystery to me then, but after I learned that they had been using the condensate from the surface condenser, which was milky, and as I knew they had always used a noncaustic compound, it was easy to understand the cause of the trouble. After they discontinued the use of the milky condensate, they had no difficulty.

I have witnessed some very distressing tube trouble due to an excess of soda ash in the feed water where softening plants are installed. My theory is that such an excess causes the water in the tubes to foam and prime out of the tube or away from the side exposed to the fire, with the result that the tube is burned. Tubes are not burned even when running the boiler at 300 per cent. rating where natural water is used.

Many tubes are lost because of the blowpipe action of the flames and gases. This is well known among designers of high-grade boilers, but we never hear anything about it from operating engineers. This results from the arch being too close to the tubes and also from restricted area or volume in the first pass. Baffles located behind the first or front row of tubes in some types of boilers will cause a great loss of tubes.

The absence of baffles on top of the first pass adjoining the vertical baffle will produce a blowpipe action which will cause bagged tubes near the baffle. Leaky baffles will also cause a blowpipe action. Extreme air pressure, say 4 to 5 in., on underfeed stokers often causes tube trouble where the fires are not given proper attention. Boilers should not be driven in excess of 150 per cent. rating where bad water must be used. This should be adhered to as a "safety first" measure. Nothing can be gained by snap judgment; it is a matter of careful analysis and good judgment to prevent the loss of tubes in water-tube boilers.

The Construction of 120- and 240-Volt Electromagnets and Solenoids

By HENRY W. TOWNSEND

Data are given for the construction of a number of 120- and 240-volt electromagnets and solenoids. The theory of the design is not gone into—the data given being sufficient to show what may be expected of the magnet after it is built.

IN A PREVIOUS article data were given on the design of electromagnets and solenoids to operate on battery circuits up to 15 volts. Going beyond this voltage, in general, means about 120 or 240 volts for lighting and power circuit, and it is on these voltages that the practical electrician and power-plant operating engineer frequently has the problem of building solenoids or electromagnets; therefore the designs in this article are chosen to meet some of these conditions.

Fig. 1 gives the working dimensions of a small 120-volt direct-current double-pole lifting magnet that has a lifting capacity of 28.5 lb. when using a current of 0.1 ampere. Each coil is wound with approximately 1.65 lb. No. 30 B. & S. gage enameled wire and has a resistance of 550 ohms; total resistance, 1100 ohms.

Wind the coils as evenly as possible, placing a layer of thin paper on every three layers to keep the winding even and smooth. All iron parts are of soft wrought-iron stock. The bobbins are formed by mounting fiber disks on each end of the core, as indicated in the figure. Three layers of paper, well shellacked, are wound around each core before winding on the wire. Drill slanting holes through the fiber ends of the bobbins for bringing out the flexible leads. It is always best to wind a layer

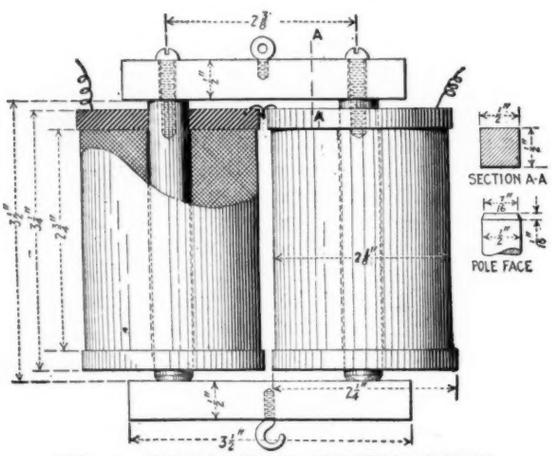


FIG. 1. DOUBLE-POLE ELECTROMAGNET

of cord or thin fiber over the outside of the coils to protect them against mechanical injury.

Connect the two coils in series to give resultant north and south poles. The pole faces are chamfered off as shown in the figure to increase the flux density at contact with the armature. This electromagnet is suitable for constant duty, the coils being designed so that the conductors have about 1000-circ.mil cross-section per ampere. This has been found good practice and need not be exceeded except in very large magnet windings of over two or three inches in depth, where the heat is dissipated with difficulty. For intermittent duty, wire of about 570- to 800-circ.mil cross-sectional area per ampere is suitable.

The principal dimensions of a 120-volt direct-current single-pole solenoid are shown in Fig. 2. The manner of mounting the solenoid on two brass straps secured to the wrought-iron yoke is indicated at *B*. The core may be made of mild cold-rolled steel. The coils of all

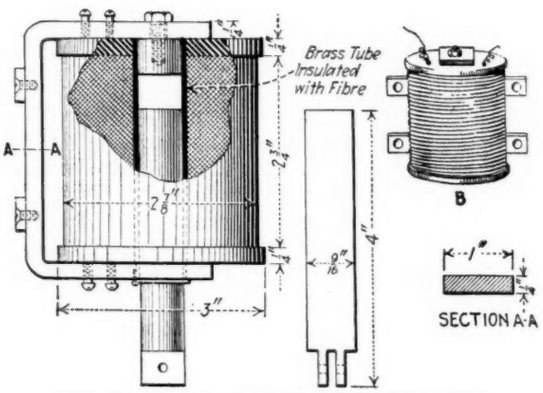


FIG. 2. SMALL SINGLE-POLE SOLENOID

solenoids must have a brass tube for the core to slide in. The bobbin is made by placing a layer of thin fiber around the brass tube and pressing the fiber end disks over the fiber layer and gluing them in place, as this will allow removing the tube after the coil is wound, so that the solenoid may be assembled. The coil is wound in even layers with 3 lb. of No. 28 B. & S. gage enameled wire, giving it a resistance of approximately 366 ohms. The current taken on 120-volts is 0.3 ampere direct, which gives about 3342 ampere-turns. The pull in pounds at different strokes are as follows: At $\frac{3}{4}$-in. stroke 2.5 lb.; $\frac{7}{8}$-in., 2.25 lb.; $1\frac{1}{4}$-in. 1.8 lb.; $1\frac{5}{8}$-in., 1.4 lb.; and at 2-in., 1 lb.

The design for a medium-sized 120-volt direct-current single-pole iron-clad solenoid is given in Fig. 3. The iron yoke is formed and placed around the coil bobbin after it is wound. The opening in the yoke is joined by a wrought-iron lap plate, with four machine screws tapped into the yoke as shown. The yoke is of soft wrought iron and the core may be of the same stock or mild cold-rolled steel. Do not make the core too tight a fit in the brass tube; $\frac{1}{64}$-in. or $\frac{1}{32}$-in. clearance between the core and tube is generally allowed on small direct-current solenoids. The bobbin is wound with approximately 3 lb. 3 oz. of No. 27 B. & S. gage single-cotton-covered magnet wire, giving a resistance of about 238 ohms and taking a current at 120 volts, of 0.5 ampere. With the core all the way in, a total maximum pull of 20.5 lb. was developed on test. At a stroke of 1-in. the pull was 6 lb.; at 2-in., 3.5 lb.; at $2\frac{1}{2}$ in., 2.5 lb.

Fig. 4 shows the design features of a large-sized 240-volt direct-current iron-clad single-pole solenoid having a pull at 1-in. stroke of 20 lb. The magnet spool is wound with approximately 8 lb. of No. 26 B. & S. gage enameled magnet wire, and the bobbin is made as de-

scribed for Fig. 2. The resistance of the coil is 419 ohms, and the current on 240 volts is approximately 0.5 ampere. For 120 volts wind the coil with the same quantity of magnet wire three sizes larger, or No. 23. The various pulls in pounds at different strokes were not tested, but can be readily judged by the relative pulls obtained with the other solenoids.

The curves, Fig. 5, give the general characteristics of both the simple and iron-clad solenoids. Curve *A* shows the pull for various strokes of the core for a simple solenoid. Curve *B* indicates the pull obtained from the same coil when provided with an iron return magnetic circuit or yoke. The difference between the two is much more noticeable at higher degrees of magnetization. Note the pull developed by the iron-clad type of solenoid near the end of the stroke, as well as the uniform pull for considerable distance at the center of the coil. The yoke is left solid at the top end, a hole being drilled through it at the bottom only, to permit

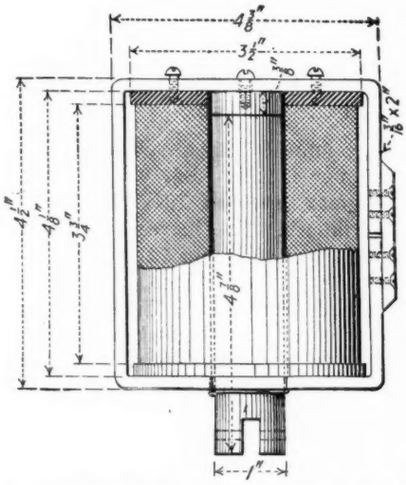


FIG. 3. MEDIUM-SIZE, SINGLE-POLE SOLENOID

the iron core to enter the solenoid. The efficient pull for iron-clads solenoids extends for about 0.6 of its length, measuring from the inside face *X* of the yoke at the top, as indicated in Fig. 5.

When an electromagnet or solenoid is built make a careful electric and magnetic lift test. The data thus obtained will prove valuable for further reference. Take pull readings every inch or half inch for solenoids and construct pull curves for various actions like those shown in Fig. 5.

Fig. 6 shows the working dimensions for building a magnetizing electromagnet that can be used for tractive or lifting purposes, etc. Any form of poleshoes may be forged out of wrought-iron stock to suit the kind of work in hand. The poleshoes shown are used for magnetizing small permanent steel magnets, such as telephone receiver magnets. Similar poleshoes, but designed with wider faces, carefully filed or machined off, can be used for magnetizing small magneto field magnets. In magnetizing such magnets, it has been found by experience that opening and closing the circuit several times per minute gives best results, made while the magnet is held in contact with the poleshoes. Some concerns employ a special automatic relay arrangement for the purpose, which opens and closes, or shunts the magnet coil circuit rapidly, at the rate of two to four seconds per interruption.

Usually, a permanent magnet will be fully magnetized after one to three minutes. The steel for the magnet should be heated a cherry red and plunged into water, making it glass hard. The harder it is the greater its retention of magnetism. Knocks and jars tend to weaken permanent magnets. They are sometimes "aged" artificially where great constancy is essential, as in electrical instruments, by placing them in boiling water, by lightly rapping with a vibrating device, such

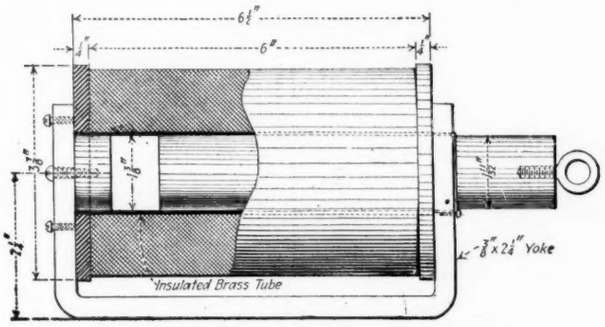


FIG. 4. LARGE-SIZE, SINGLE-POLE SOLENOID

as an electric-bell movement, or by a mechanical rapper.

The spools for the coils are made by placing on the iron cores ⅛-in. fiber disks drilled or bored out to fit tightly on the core ends. The cores are then covered with three layers of oiled linen or heavy paper, well shellacked. Be sure the oiled linen comes up tight against the fiber disks to prevent the possibility of a "ground" due to wire touching the iron core.

The magnet as originally built, to stand up under all-day service, was calculated to allow about 1400 circ.mil per ampere for the magnet-wire cross-section. Hence

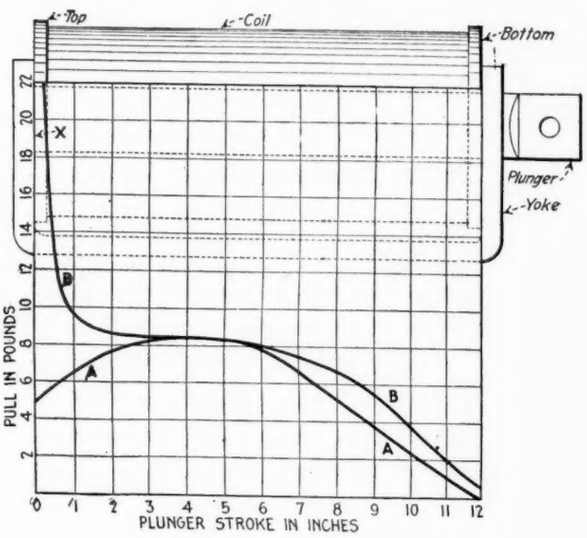


FIG. 5. SOLENOID CHARACTERISTIC CURVES

where cool operations for long periods are desired the following windings can safely be used, giving a total of about 9000 ampere-turns for the two poles. Each coil is wound with 15¼ lb. No. 22 B. & S. gage enameled magnet wire in even layers, using a layer of paper every two or three layers to keep the winding even. Always test the coil for continuity periodically as the winding progresses, as this may save much labor and time. The No. 22 wire coils, connected in series, give 253 ohms resistance, and the current will be 0.434 ampere on 110-

volt direct-current. The total pull is approximately 300 lb.

For semi-intermittent service, where a stronger magnetization is desirable, the coils can be wound with 15¼ lb. No. 20 B. & S. gage enameled wire. This gives a total of 15,430 ampere-turns. The resistance of each spool is 49.5 ohms, or 99 ohms for the two coils in

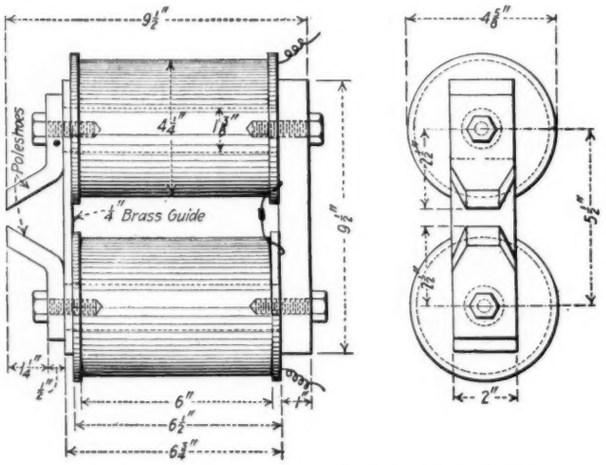


FIG. 6. MAGNETIZING ELECTROMAGNET

series. The current on 110 volts is 1.11 amperes. The circular mils per ampere in this case are 920 or still in the safe operating field. For plain lifting or traction work use an armature of the same size as the yoke, or if iron plates, etc., are to be picked up, then these of course form the armature. By arranging the polepieces to suit, this magnet can be adapted to a wide variety of work such as for magnetic separators, operating various mechanical devices, etc.

Electric Light and Power*

BY SIDNEY GRAVES KOON, M.M.E.

In studying the census figures showing the growth of the electric light and power industry from 1907 to 1912 and 1917 there are many items of interest which do not appear on the surface. Some of these follow.

1. *The Unit or Average Plant*—The figures for 1907 show a total of 4714 "establishments" providing central-station service, this number increasing to 5221 in 1912 and 6541 in 1917. Dividing the principal items in the report by these figures, successively, the average plant appears to have grown as follows:

	1917	1912	1907	Per Cent. Increase 1907 to 1917
Total income	$80,551	$57,896	$37,260	116.2
Income from electric service	76,762	54,997	35,981	113.3
Total expenses	65,301	44,930	28,468	129.4
Salaries and wages	14,560	11,715	7,514	93.8
Persons employed	16	15	10	60.0
Primary horsepower	1,966	1,442	869	126.2
Kilowatt capacity	1,376	989	575	139.3
Output, kilowatt-hours	3,889,101	2,215,880	1,243,588	212.8

2. *The Financial Changes*—In 1907 the electric-service income ($169,614,691) represented 96.57 per cent. of the total income ($175,642,338). In 1912 the electric-service income ($287,138,657) represented 94.99 per cent. of the total income ($302,273,398). In 1917 the electric-service income ($502,100,346) represented 95.3 per cent. of the total income ($526,886,408). This left 3.43 per cent. for "all other income" in 1907, 5.01 per cent. in 1912, 4.7 per cent. in 1917. The growth of the electric-accessory business during the five years from 1912 to 1917 appears to have been more apparent than real, as measured in terms of energy consumption, for it failed to keep pace with the growth in income from electric service.

Total expenses in 1907 were 76.4 per cent. of total income. Whether these "total expenses" include taxes was not stated, but the expense ratio leads one to believe that the taxes were included. In 1912 the corresponding expense ratio was 77.6 per cent. In 1917 it was no less than 81.07 per cent. The evidence of steady increase in this figure is what would have been anticipated by anyone familiar with conditions in the industry. But the next deduction comes as something of a surprise—that the relative amount paid for wages has fallen as compared with total income and with total expenses. The table shows the ratios.

	1917	1912	1907
Salaries and wages	$95,239,954	$61,161,941	$35,420,324
Percentage of			
Total income	18.0	20.23	20.17
Total expenses	22.3	26.07	26.4

The average annual "pay envelope on 1907 contained $744, or $62 per month. In 1912 this had advanced to $771 per year, and, in 1917, to $902, or a little over $75 per month. The increase from 1907 to 1912 was only 3.63 per cent.; from 1912 to 1917 it was 16.99 per cent.; over the whole period, 1907 to 1917, the advance was 21.24 per cent. These figures were not enough, however, even combined with the increase of 121.6 per cent. in number of total employees, to bring the total payments up to the proportionate figure for earlier years, as compared with either total expenses or income.

Income from electric service, divided by output in kilowatt-hours shows an average of 2.893 cents per kilowatt-hour in 1907, falling 14.2 per cent. to 2.482 cents as an average for 1912, and a further 20.5 per cent. to the 1.974 cents of 1917. The total drop in "unit" income over the ten-year period was 0.919 cent, or 31.8 per cent.

3. *Primary Power*—The Census report gives the number of prime movers and the rated total horsepower of each of the three main types. A study of the change in average sizes shows some surprising figures for growth, when the briefness of the intervals is considered. The average steam engine in service has much more than trebled in size in ten years, while the average waterwheel has more than doubled. The gas and oil engines have actually diminished in average size. Thus:

	1917	1912	1907	Per Cent. Increase 1907 to 1917
Steam engines:				
Number	7,464	7,847	8,054	—7.3
Horsepower	8,389,389	4,949,778	2,693,273	211.5
Average	1,124	631	334	236.5
Gas and oil engines:				
Number	2,946	1,116	463	536.3
Horsepower	217,186	111,035	55,828	289.0
Average	74	99	121	—38.8
Waterwheels:				
Number	3,357	2,939	2,481	35.3
Horsepower	4,251,423	2,469,231	1,349,087	215.1
Average	1,266	840	544	132.7
Total prive movers:				
Number	13,767	11,902	10,998	25.2
Horsepower	12,857,998	7,530,044	4,098,188	213.7
Average	934	633	373	150.4

In spite of the slogan of "conservation," as applied to coal and fuel oil, the power derived from hydraulic

*An analysis of the census figures for the United States, published in *Power*, Apr. 22, 1919, page 627.

plants scarcely more than kept abreast of the growth of the steam plants. The percentages of the total primary power furnished by each type of prime mover follow:

	1917	1912	1907
Steam engines	65.25	65.73	65.72
Oil and gas engines	1.69	1.47	1.36
Waterwheels	33.06	32.8	32.92

Steam turbines are of course responsible for most, if not all, of the great growth in aggregate horsepower of steam engines in the central stations. It is not unlikely that a positive decline has taken place in both the number and the total power of reciprocating engines engaged in this service during the decade under review.

The average capacity in kilowatts of the generators attached to each prime mover has increased from 246 in 1907 to 443 in 1912 and 654 in 1917; an over-all increase of 165.9 per cent. The total capacity of the plants, in kilowatts per person employed, has advanced from 57 in 1907 to 65 in 1912 and 85 in 1917—a gain in ten years of about 50 per cent. This is due in large degree, of course, to the heavy increase (150.4 per cent.) in the average capacity of prime movers. Quite likely the more general use of automatic stokers was another large factor in keeping down the number of employees.

The mechanical efficiency of the generating units showed a steady gain during the period, for the kilowatt capacity of dynamos per horsepower of prime movers advanced from 0.661 in 1907 to 0.686 in 1912 and 0.7001 in 1917, an over-all gain of 5.9 per cent.

4. *Output*—Based on 8760 hr. per year in 1907 and 1917, and on 8784 hr. in 1912 the over-all load factor showed a gratifying increase from 24.7 per cent. in 1907 to 25.5 per cent. in 1912 and 32.3 per cent. in 1917. This improvement is no less than 30.8 per cent., most of the gain coming in the most recent years. This shows well the fruits of the campaign continually being waged to "off-peak" business. It was also, in passing, doubtless one of the biggest reasons for the falling off in the average price of current per kilowatt-hour.

The output per person employed increased from 123,074 kw.hr. in 1907 to 145,826 in 1912 and 241,019 in 1917, a ten-year advance of 95.8 per cent. The growth in size of prime movers, already shown, is largely responsible for the gain of 246.7 per cent. from 532,943 kw.-hr. per unit in 1907 to 1,847,796 in 1917. The figure for 1912 was 972,031 kw-hr. for each prime mover.

Motors connected (aside from railway motors) more than trebled in number in the decade, and nearly doubled in individual average rating, having increased from 9.86 hp. in 1907 to 16.6 in 1917, a gain of 68.4 per cent. Motors appear to be taking a greater and greater share of the output of the stations. Figures for total conected load are not given, but the total motor horsepower was 71.7 per cent. of the total prime-mover horsepower in 1917, as compared with 54.9 per cent. in 1912 and only 40.2 per cent. in 1907. The ten-year gain in this ratio was 78.4 per cent.

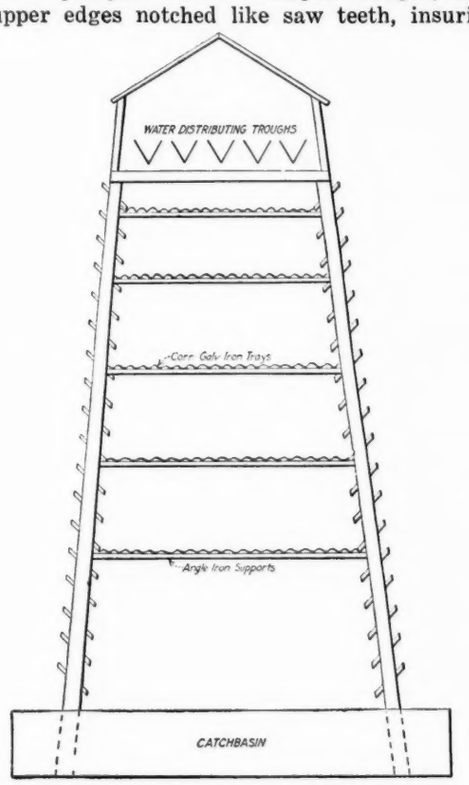
In the future the principal use of high-volatile coals will be in the byproduct gas plants because of the higher commercial value of the products of carbonization. It is even suggested that the time may come when our views of the relative values of the different coals will change and we shall consider anthracite as of minor importance as compared with the high-volatile bituminous coals.

Cooling Tower for Refrigerating Plant

By A. Giger

The following is a description of a cooling tower that has been giving excellent results. The sketch shows an end view of the tower with louvre boards removed to enable the reader to readily note its construction. The general construction is similar to that of many others in use, the chief difference being that instead of using the wooden crisscross, or checker-board, pattern for baffling the water, this tower uses the ordinary 26-gage galvanized corrugated iron, making a cheaper and much more effective means of cooling the water.

Water is pumped to the V-shaped troughs, having their upper edges notched like saw teeth, insuring a



SECTION OF "HOME-MADE" COOLING TOWER

uniform distribution, provided the troughs are level and notches are of uniform depth. From these troughs the water falls to the corrugated trays, these latter completely covering their respective sections of the tower. The concave or gutter corrugations of these trays or galvanized sheets have holes punched in them, the size and distance apart depending upon the size of the trays and the amount of water that it is desired to circulate. In this particular tower the holes are $\frac{5}{16}$ x 4 in. centers, and were made with an ordinary belt punch and hammer. The water as it leaves the distributing troughs falls to the first tray, spreading and finding its way through holes down to the second tray, the second as well as the others being made the same as the first one, the water finally ending up in the catch basin, whence it goes to the condensers. Trays are kept in position by means of angle bars or timbers fastened to the tower frame. The water as it falls to the trays has no chance to accumulate or gather to any depth, but is more in the shape of a thin film; and owing to the trays being made of very light iron and the unrestricted passage of air through the tower, good results are obtained.

Operation at Holtwood—Features of Station Operation and Maintenance

By CHARLES H. BROMLEY

A hydraulic operating board which bears the same relation to the governor and hand control that the benchboard and mimic board do to the 11,000- and 70,000-volt electrical system is located on the turbine-room floor and visible to the switchboard operator. Spare parts of hydraulic and electrical equipment are available to the crew without requisition or kep during emergencies. Vacuum in the turbine draft tubes used for cleaning the station floors. Many other interesting features are described and illustrated.

THE Hydraulic Operating Board—Midway of the turbine floor and directly across the floor from the switchboard gallery, is the hydraulic operating board, diagrammed in Fig. 2. This board bears the same relation to the governor- and hand-control systems as the benchboard and mimic board do to the 11,000- and 70,000-kw. buses. The operation of the pumps, headers, governor valves, etc., is always displayed on this board. The floorman makes the necessary indications whenever any pumps have been started, shut down or transferred, or when other changes in operation of the systems are made. The governorman makes the changes on the board following the shutting-down or starting of a unit; that is, he indicates the changes to the hand-contro and governor-control systems used for the particular unit. The operation of all governor pumps and of the No. 2 hand-control pump is indicated by red lights on the board. These lights are the same as are used on the electrical benchboard. The lamps are connected across the motor terminals. The board is made of 1-in. kiln-dried white pine, cleated, glued and framed; the dimensions are 15 x 6 ft. It is shellacked and given two coats of white-lead paint. Black stripes represent the piping connections. Valves are represented by oak buttons screwed to the board on top of ⅛-in. leather washers. When a button is in line with the pipe it indicates an open valve, and when set across the pipe it indicates that the valve is closed.

When valves, headers, pumps, etc., are cut out of service, and work is being done on them, a holdoff tag is hung directly on the operating board at the particular piece of apparatus or valve out of service. Likewise, when a main unit or an exciter unit is withdrawn from service for repairs, a holdoff tag is placed below the unit number marked on the board, while on the turbine itself the governor-control and the hand-control valves are locked, a painted iron holdoff tag forming a part of the lock chain.

One of the chief uses of the board is this: Suppose that the governor pressure is reduced considerably below normal. This will be shown on the large double-faced dial gages, one set of which is located in the turbine room and conveniently seen by the operator. A glance at the hydraulic board will tell the operator whether or not he has lost one of the governor- or hand-control pressure pumps, for if this pump is cut out of service due to disturbance on the electrical side, the red light on the board will have gone out.

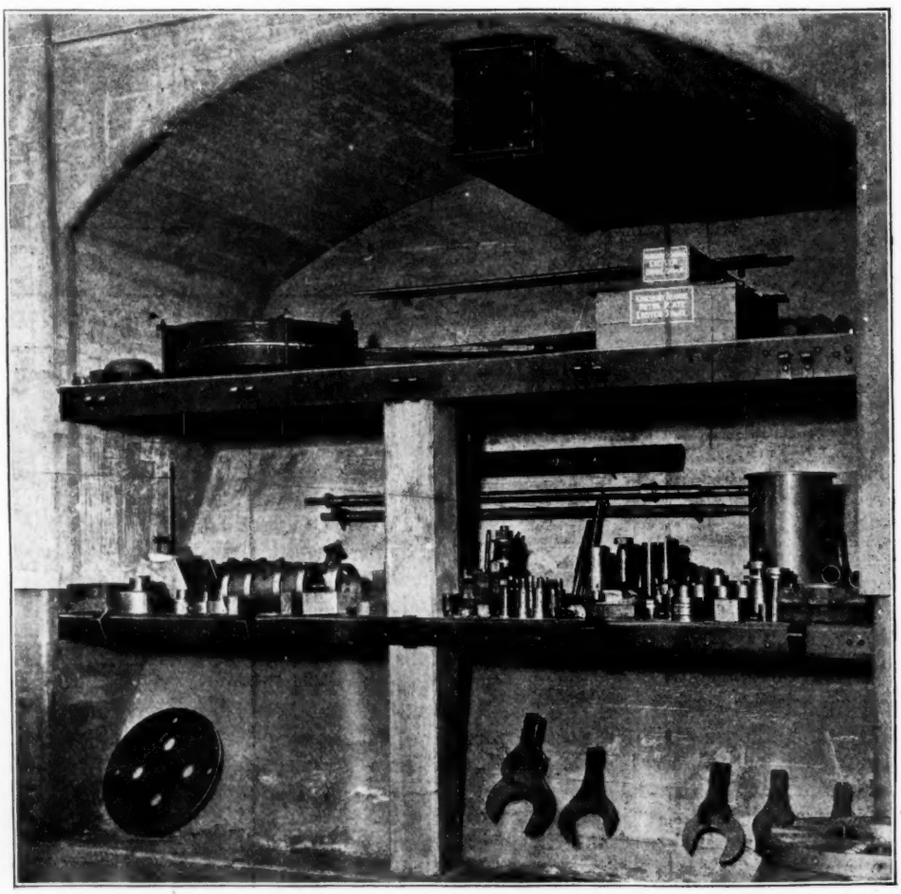


FIG. 1. SPARE GEAR IS AVAILABLE IN THE BAYS ALONG THE TURBINE ROOM FOR REPAIRS IN EMERGENCIES WHEN THE STOCKROOM CLERK IS ABSENT

Availability of Spare Parts in Emergencies—While a fully equipped stockroom is provided at Holtwood, and a stock clerk is in charge, care has been taken to make available to the crew at any hour of the day or night almost any

part or tool needed to meet an emergency, without the necessity of making out a requisition and waiting until the stock clerk comes to unlock the large outside storeroom, whenever that might be. On shelves on the turbine floor, one of which is shown in Fig. 1, are found governor heads, trunnions, main valves, pilot valves, spindles, hydraulic operating mechanism pins, nuts, bolts and liners — in fact, almost any part that might be required if something went wrong with the hydraulic system during the night when the stock clerk or chief machinist was not on duty. The stockroom of the electrical gallery likewise has its parts—fuses, etc —available at all times. On Piney Island, where the arc extinguisher is located, spare parts are kept in a shanty and are always available for emergencies. In the bays along the main turbine room large sectional drawings of the unit opposite the bay are mounted in glass cases. These drawings show sections of the main units (that is, the turbine and generator) and one shows a section of the complete assembled governor.

Cleanliness and Order in Station—Cleaning of the principal apparatus and miscellaneous auxiliary equipment is assigned to specific station attendants, and their work is checked up by the entries on the "Annual Cleaning and Inspection Charts" mounted in a glass-front case on the station wall and described in an article on Holtwood records in the issue of May 20. This cleaning work is not the only plan employed to produce the neat and orderly appearance of the station that

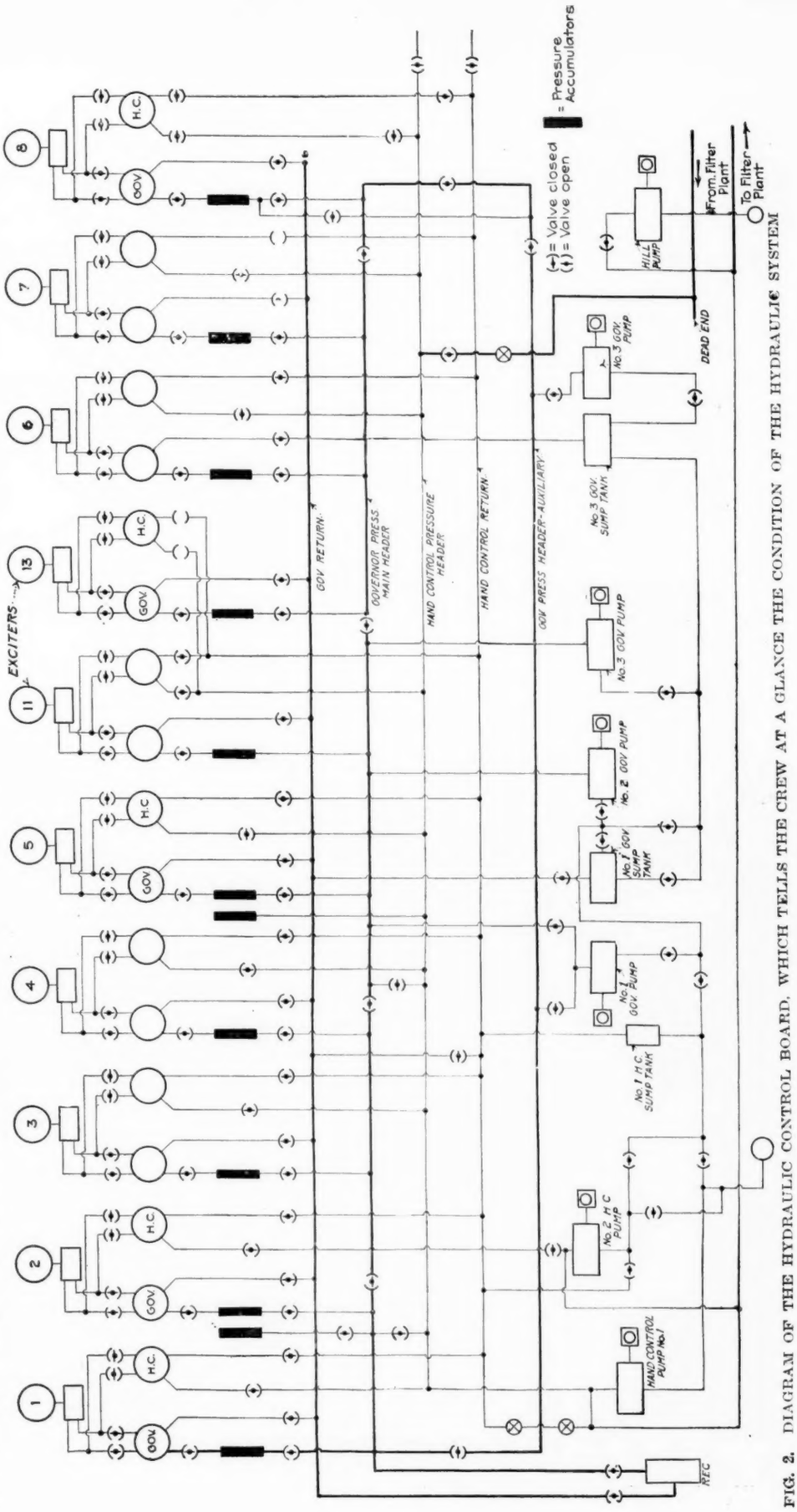


FIG. 2. DIAGRAM OF THE HYDRAULIC CONTROL BOARD, WHICH TELLS THE CREW AT A GLANCE THE CONDITION OF THE HYDRAULIC SYSTEM

impresses every visitor. Care is taken that all work around the station—handling of tools, sweeping of floors and stairways, chipping of concrete, etc.—is done in a manner that will not disturb the neat appearance of the station or interfere with operation.

For cleaning floors a vacuum system is used, connected to the draft tubes of the main turbines. The vacuum connections are provided at each unit on the main floor and at numerous other places throughout the station (see Fig. 6).

When chipping of concrete is to be done, canvas-covered wooden frames are placed around the workmen, preventing the fine dust from spreading over the station and penetrating into some of the exposed bearings of governors or auxiliary apparatus. How this is done is shown in Fig. 7.

Drinking water is provided at several fountains distributed at convenient places in the station. These are piped up through a circulating system to a small refrigerating machine, Fig. 8, thus doing away with sloppy ice-water tanks and handling of ice in the station.

Dark corners, places around drains and cuspidors, etc., are painted a shining white, so that any neglect in cleaning such parts as are susceptible to uncleanliness will show up the more strikingly. Drain-cocks mounted on different apparatus are not permitted to cause leaky spots on the floor, or around the apparatus. They are piped up to small drain lines emptying into the trench or general drain provided on each operating floor. The writer noticed also that the large pipe lines in the pump tunnel, which carry cold water and which have given a great deal of trouble, due to sweating on humid days, have been coated with a layer of ground cork, which effectually prevents sweating. Small tools that are used frequently by operating attendants when performing minor maintenance work, are kept in a wire-glass-front locker, each tool having its place marked by a white line on the wall of the cabinet. This makes it practically impossible to return a tool to any place other than where it belongs, and the absence of any tool is noticed immediately through the glass front. Minor defects to equipment that cannot be taken care of by the operating attendant on shift, but are not so essential to safe operation as to require immediate correction, are noted on a blackboard in the pump tunnel. Columns are provided on the blackboard for the

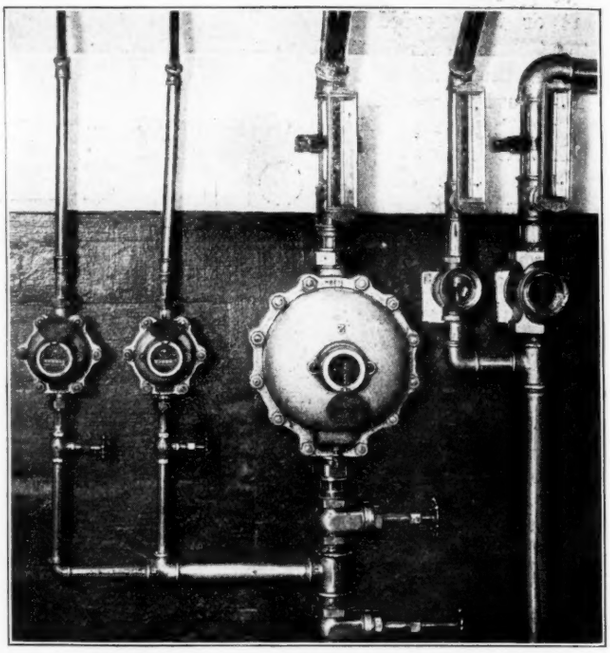


FIG. 4. METERS ON THE LINES SUPPLYING LUBRICANT

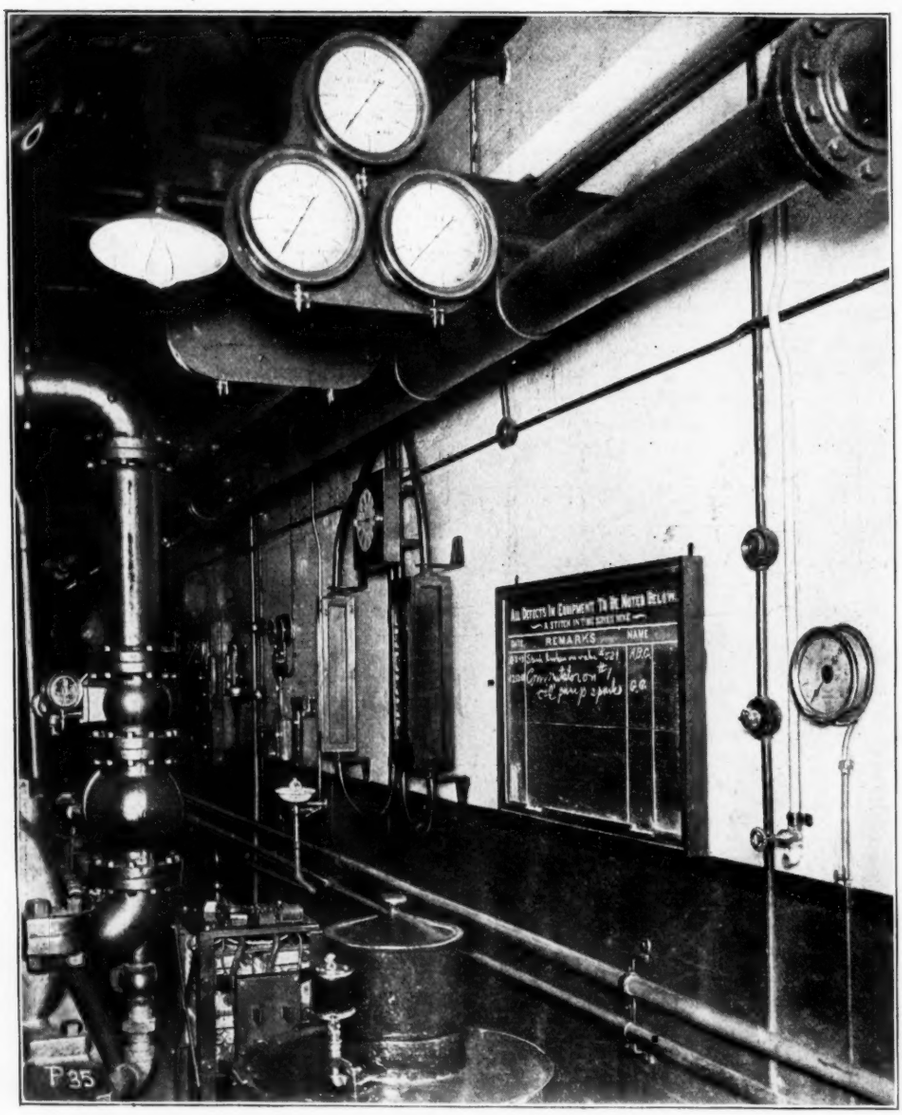


FIG. 3. VIEW IN THE PUMP TUNNEL

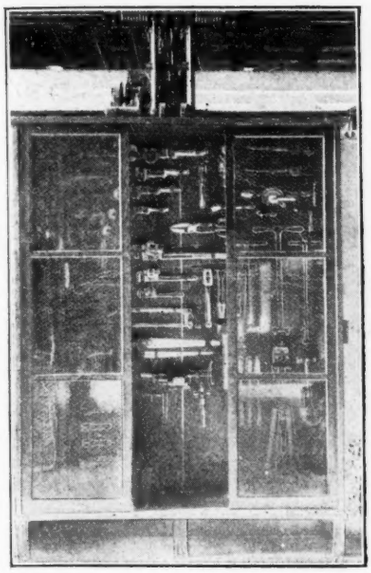


FIG. 5. WIRE-GLASS-FRONT TOOL CASE

FIG. 6. USING THE VACUUM IN THE DRAFT TUBE FOR CLEANING

FIG. 7. FABRIC HOUSING PREVENTS THE SPREAD OF CONCRETE DUST

initials of the attendant reporting the defect and also for the man who corrects it.

Illumination—The man who has worked in a tunnel will immediately appreciate the value of a system of illumination whereby bright lights are not shining in his eyes. In the pump tunnel at Holtwood the main illumination is indirect; that is, the large or open ends of the shades point up to the roof of the tunnel, instead of facing the floor, as is customary.

While sockets and plug receptacles are well distributed about the plant for the use of extension lamp cords or drop lights, each man is furnished with a large electric pocket torch or lamp. These do much to eliminate guessing and hasty judgment in observation and inspection.

Observation of the Lubricating-Oil Flow—One does not have to be emphatic to convince the reader that the lubrication of these large turbines is important. The oil-supply and the oil-return pipes are of course provided with sight glasses so that the crew may tell at a glance whether or not the oil-pipe lines are obstructed. Oil-flow meters, thermometers and flow indicators are arranged as far as practicable in a compact group, well illuminated, permitting convenient and accurate observation. One additional little thing is done at Holtwood that the writer has noticed a lack of elsewhere —where these sight glasses are next to a dark wall the wall in back of the glass is enameled white. It is not likely, therefore, that the man making the observation will be mistaken, as the stream of oil is plainly visible, just as absence of the stream is indicated by a solid white background.

Precautions When Cutting in New Thrust Bearing—Roller bearings on the main units at Holtwood have not

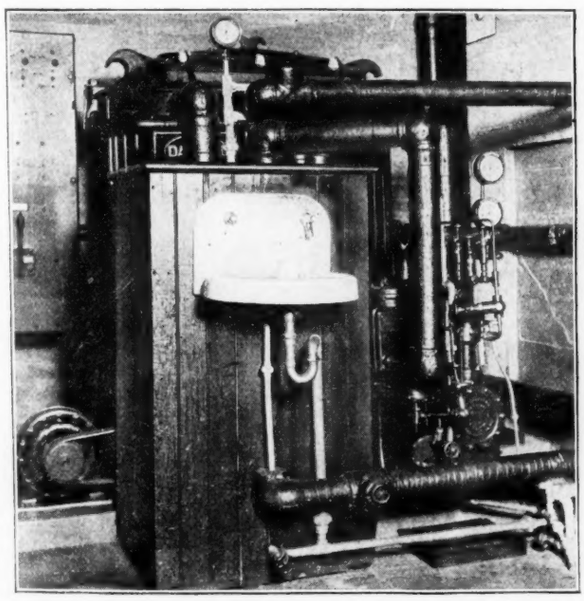


FIG. 8. THE REFRIGERATING MACHINE FOR COOLING THE DRINKING WATER

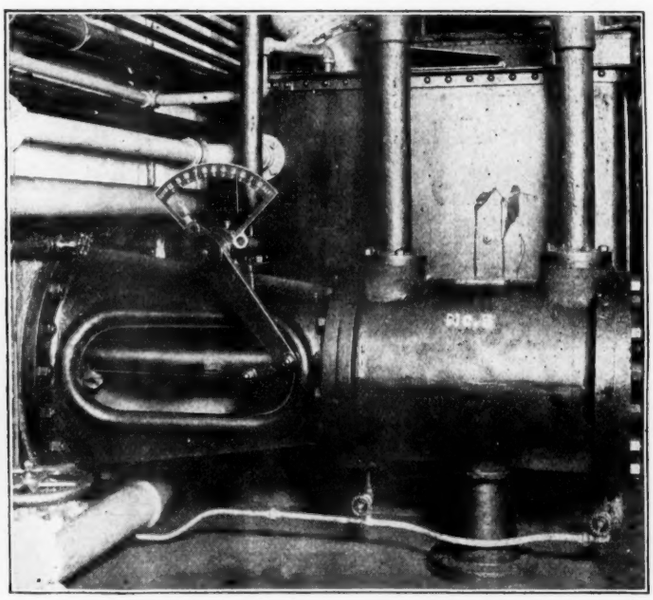


FIG. 9. OPERATING CYLINDER FOR MOVING THE GATES OF THE TURBINE. THE INDICATOR SHOWS THE POSITION OF THE GATES

been as successful as the operators would desire, and thrust bearings, in which the bearing surface is made up of a number of sectors resting in spherical seats and using an oil film at high pressure, have been provided. When first cutting in a new Kingsbury thrust bearing at Holtwood, the following precautions are observed: The floorman supervises the operation of starting and stopping the unit which has the new bearing in it. The temperature of the oil is closely watched for the first twenty minutes that the unit is running. During this time the temperature of the oil should not increase more than 2 deg. C. If it rises more rapidly, the unit is shut down and the chief operator is immediately notified. For the first thirty days that the unit is in service half-hourly readings of the oil temperature in the oil housings are taken and entered in a separate log sheet provided for this purpose. The unit is kept on hand control for a few days.

As most readers know, these bearings are designed to make use of the principles of lubrication made famous by Tower, who first discussed them before the Royal Society. The load is supported on a film of oil. For each of the 13,500-hp. turbines at Holtwood the total load on the thrust bearing is 410,000 lb., the speed is 94 r.p.m.; yet after six years' service the wear on the shoes is so slight as to be difficult of measurement.

The following data are from the tests on one of these bearings at Holtwood:

Total load on bearing, lb	410,000
Area of shoes, sq.in.	1,160
Unit pressure per sq.in., lb	350
Speed, r.p.m.	94
Mean surface speed, ft. per min.	900
Kind of oil	Light Mineral
Oil flow through bearing per minute, gal.	15
Mean temperature rise in oil, deg. F	4.5
Frictional loss in bearing, hp.	9
Coefficient of friction	0.0008

Welding a Wrecked Rolling-Mill Engine Cylinder

By L. M. Malcher*

One of the big steel rolling-mill engines at the works of the Carnegie Steel Co., Farrell, Penn., which had been doing its full share in helping to win the war, broke down two weeks after the signing of the armistice, having worked constantly up to then on war orders. In

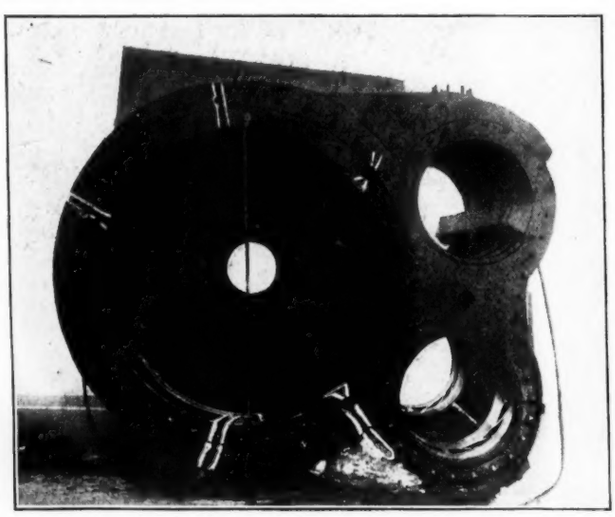


FIG. 1. WRECKED LOW PRESSURE CYLINDER, SHOWING CRACKS V-GROOVED BY CHIPPING PREPARATORY TO OXWELDING

*Superintendent, Welding Shop of Oxweld Acetylene Co.

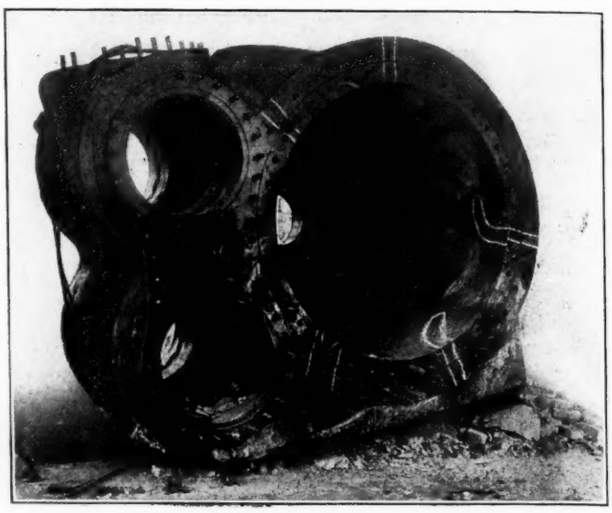


FIG. 2. WELDING OF LOW PRESSURE CYLINDER COMPLETED

the accident, besides other parts, the 54 x 70-in. left-hand low-pressure steam cylinder of a twin-tandem compound reversing engine was badly fractured, as a result of the breaking of a connecting-rod at the moment of reversal.

A serious situation confronted the officials of the company as it would have taken three months or more to obtain a new cylinder. Three hundred and sixty men were thrown out of employment. The broken cylinder, in which there were seven cracks which totaled 22 ft. 2 in. in length, was of such size and the damage done was of such character that a decision whether the cylinder was to be renewed or repaired involved a risk on the part of the management. Although considerations of expense as between the cost of purchasing a new cylinder and repairing the old one were of secondary importance, the cost of repairing was estimated to be about one-third that of a new cylinder.

The officials of the company after investigation decided in favor of oxyacetylene welding. They called upon the job welding shop of the Oxweld Acetylene Co., Chicago, Ill., to meet the emergency. Three expert welders, accompanied by all necessary equipment, went immediately to Farrell and completed the job under the direction of the writer. The time consumed in repairing the cylinder, including chipping, preheating and welding, was 72 hours.

While dismantling the engine a fracture was discovered in the right hand, 42-in. high-pressure cylinder. This also was repaired in about 18 hours. It took just seven days from the time the order was given to complete the entire job.

While welding inside of the cylinder, the men relieved one another every ten minutes because of the extreme heat deflected back on them during the welding operation. On the outside welding, however, the heat was not so intense and the men relieved one another every thirty minutes.

After the engine cylinders were machined, it was almost impossible to determine where the cracks had been. The total cost of this repair represents but a small fraction of the replacement cost, but even this saving is insignificant when compared with the disorganization that would have resulted from the laying off of a large body of trained workmen and with the enormous loss that would have been caused by a stoppage of production.

Fusibility of Ash From Pennsylvania Coals*

By W. A. SELVIG and A. C. FIELDNER

Introduction

PREVIOUS papers[1] gave a description of the standard gas-furnace method used by the Bureau of Mines in making ash-fusibility tests, a discussion of the relation of fusibility tests to clinker formation, and tables giving a summary of results obtained for the coals of West Virginia and the interior province. This paper includes a table giving a summary of such tests on the coals of Pennsylvania, which state is by far the greatest coal-producing state in the union.

Interpretation of Fusibility Table

The various coal beds of the bituminous coal field of Pennsylvania are arranged according to their geological succession, the uppermost beds being listed first. The samples tested are practically all standard mine samples collected according to the methods used by the Bureau of Mines.[2] A few car samples which were considered representative of the output of the various mines were also included.

The various coal districts of the anthracite region are arranged alphabetically under the field to which they belong. The samples are practically all delivery samples of the various sizes as marketed; only a few standard mine samples are represented.

The number of mines sampled, number of samples represented, average softening temperature in degrees F., per cent. ash and per cent. sulphur on the dry-coal basis are given for each bed tested in the bituminous coal field and for each district in the anthracite region. Average values for each mine were computed from the individual samples, and from these values averages representing each bed or district were obtained. In some instances the average values given for the beds or districts represent only a few mines and are in such cases not truly representative. The point taken as the softening temperature is that at which the ash when molded into solid triangular pryamids $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. wide at the side of the base, and mounted in a vertical position has fused down to a spherical lump. Samples remaining unfused at 3010 deg. F., which was the highest temperature attained in the test, were marked plus 3010 (+3010) and used as such in figuring the average values for the mine from which the average values of the beds or districts were computed.

Discussion of Fusibility Values

As stated in a previous paper[3] on the fusibility of coal ash from the interior province coals, the softening temperature of coal ash from the various fields of the United States range in general from 1900 to 3100 deg. F., this range of softening temperature for convenience in discussion being subdivided into the three following groups:

Class 1: Refractory ashes, softening above 2600 deg. F.

Class 2: Ashes of medium fusibility, softening between 2200 and 2600 deg. F.

Class 3: Easily fusible ashes, softening below 2200 deg. F.

The softening temperature of the ash from the bituminous coal field of Pennsylvania are found in Class 1 and Class 2, principally in the latter. The beds of the Monongahela, Conemaugh and Allegheny series, with the exception of the Lower Kittanning, Fulton and Brookville beds of the Allegheny series, are uniform as regards fusibility and come in Class 2. The Lower Kittanning bed of the Allegheny series contains a large number of mines that give ash of high fusibility, and the average for this bed almost places it in the lower part of Class 1. The Fulton and Brookville beds of the Allegheny series, as also the Bloss bed of the Pottsville series, come in Class 1.

It is interesting to note that the coals that show high softening temperatures are geologically the lower and older beds of the bituminous coal field. This was also found to be true of the coal beds of West Virginia. It has been found that in general the beds of the Monongahela and Allegheny series of Pennsylvania give a more refractory ash than do the same beds as found in West Virginia.

The ash from the anthracite region of Pennsylvania is refractory, coming in Class 1. The softening temperature in practically every instance is above 3000 deg. F.

FUSIBILITY OF ASH FROM PENNSYLVANIA COALS

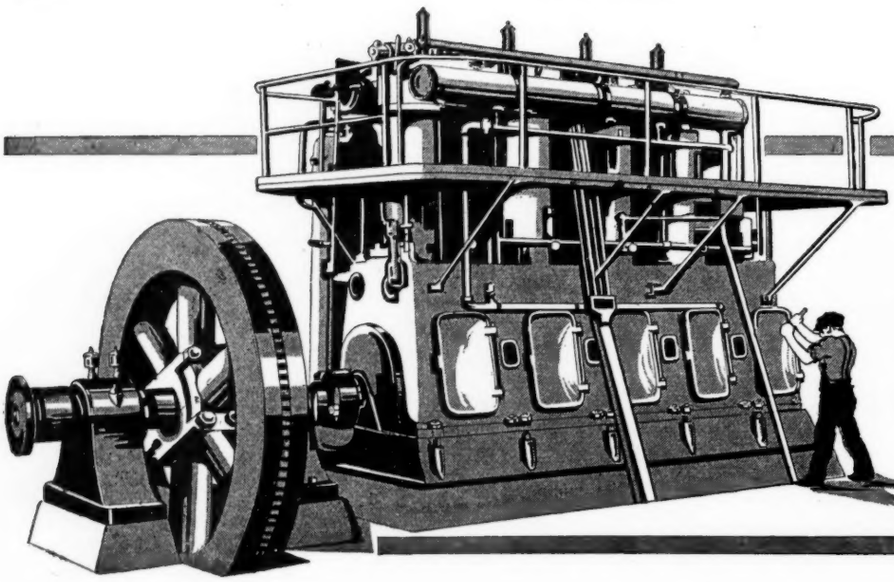
Series, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Deg. F.	Ash in Dry Coal, Average Per Cent.	Sulphur in Dry Coal, Average Per Cent.
Bituminous Region					
Monongahela Series:					
Pittsburgh Bed	10	34	2360	7.17	1.43
Conemaugh Series:					
Little Pittsburgh Bed	1	2	2390	8.13	1.70
Allegheny Series:					
Upper Freeport (E or Lemon) Bed	33	85	2350	9.35	2.13
Lower Freeport (D or Moshannon) Bed	21	70	+2390	8.52	2.06
Upper Kittanning (C Prime) Bed	7	18	+2350	8.67	2.16
Middle Kittanning (C) Bed	5	7	+2380	11.06	2.98
Lower Kittanning (Miller or B) Bed	39	162	+2550	7.86	2.03
Fulton bed	4	12	+2940	7.36	1.18
Brookville (A) Bed	3	3	+2800	12.98	1.86
Pottsville Series:					
Bloss Bed	3	3	2630	11.96	2.25
Anthracite Region					
Northern Field:					
Pittston District	1	1	+3010	6.03	0.58
Plymouth District	2	7	+3010	12.52	0.84
Scranton District	6	7	+3010	12.39	0.79
Wilkes-Barre District	3	4	+3010	13.17	0.78
Eastern-Middle Field:					
Hazelton District	1	1	2960	14.50	0.61
Western-Middle Field:					
Shamokin District	2	2	+2960	16.59	0.90
West Mahony District	3	3	+3010	.....	....
Southern Field:					
East Schuylkill District	2	2	2990	11.19	0.78
West Schuylkill District	1	1	2730	18.07	0.82

Note: A plus sign (+) placed before a given value denotes that the true value is above that indicated.

*Published by permission of the Director, United States Bureau of Mines.

[1]Selvig, W. A.; "Fusibility of Ash from West Virginia Coals," *Power*, p. 566, Oct. 15, 1918; *Chemical and Metallurgical Engineering*, Vol. 19, No. 12, 1918, pp. 826-8.
Selvig, W. A., Ratliff, W. C. and Fieldner, A. C.; "Fusibility of Ash from Great Lakes and Mississippi Valley Coals," *Power*, April 1, 1919, p. 479; *Chemical and Metallurgical Engineering*, Vol. 20, No. 6, 1919, pp. 274-6.
For complete tables giving results obtained for each mine tested see: Selvig, W. A.; "Fusibility of Coal Ash from West Virginia Coals," *Coal Age*, Vol. 15, No. 1, 1919, pp. 12-16. Selvig, W. A., Ratliff, W. C., and Fieldner, A. C.; "Fusibility of Ash from Coals Found in the Interior Province," *Coal Age*, Vol. 15, No. 16, 1919, pp. 698-703.

[2]Holmes, J. A.; The Sampling of Coal in the Mine; Technical Paper 1, Bureau of Mines, 1911, 18 pp.



Talks on DIESEL Engines

by L. H. Morrison

XX—The chief brings to a close his series of informal talks, the subjects for the final meeting being the efficiency of the Diesel engine, as compared with other prime movers, and the necessity of keeping daily records.

"CHIEF," said Kelly, as Egan sat down at his desk, "you say that the Diesel engine is the cheapest power, and still you hedge."

"How so?" Egan smilingly hunted for a match.

"I heard you say to-day that a gas engine didn't use any more heat units than a Diesel."

"Those two statements don't conflict, Kelly. The gas engine might use less heat units and still be more expensive to run than an old slide-valve steam eater. You must look into the cost of the heat units to decide which is the cheapest. Even though the gas engine equalled the Diesel in thermal efficiency, it usually will be the more expensive to run."

"What do you mean by thermal efficiency?"

"That means the percentage of the heat supplied by the fuel that is actually used by the engine in developing power in the cylinder. The thermal efficiency of a Diesel will not exceed 38 per cent. in operation, though in factory tests 40 per cent. has been obtained. This, though, usually includes the extra power that the air injection supplies. The real meat of the affair is the efficiency per brake horsepower. The value that this will show in an engine in operation at around full load, is from 25 to 30 per cent. A good gas engine on full load will show up as well. On the lighter loads, the gas engine cannot equal the Diesel. The efficiency in either engine depends to a considerable extent on the compression pressures. In the Diesel this pressure is fairly constant at all loads, since a full air charge is drawn in even at low loads. With the gas engine, at low loads, the mixture of air and gas is leaner and the compression pressure falls off a corresponding amount.

"Fig. 1 shows the results of two tests we ran on a four-cylinder vertical 200-hp. gas engine and a four-cylinder 500-hp. Diesel, the gas-engine curve being the lower one. At full load the brake efficiency is the same, but at the low loads the Diesel shows up better. Taking the efficiency on the basis of cost, let's see how they pan out. Our Diesel fuel oil costs us 3.32c. per gal. Natural gas at the turbine plant is purchased for 8c. per thousand cubic feet. First, figuring on the Diesel, we find it requires 8380 B.t.u. per brake horsepower at full load. Oil costing 3.32c. per gal. means 0.4c. per pound

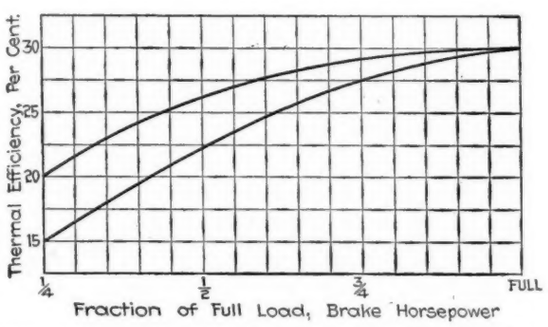


FIG. 1. COMPARISON OF DIESEL ENGINE AND GAS ENGINE PERFORMANCES

of 18,000 B.t.u. Consequently, the cost per brake horsepower is $\frac{8380}{18{,}000} \times 0.4 = 0.186$c. or 1.86 mills. Checking the gas engine we find the gas contains 800 B.t.u. per cu.ft., and so 8380 B.t.u. would cost 0.084c. or 0.84 mill. The gas engine would therefore be the more economical."

"That's pretty cheap for gas. It's costing me 50c. per thousand."

"That's because you are a domestic consumer, Woods. With a gas engine the consumption is not as great as in a steam plant, so the cost would exceed the 8c. which applies at the turbine plant where millions of feet of gas are used each month. A cost of around 25c. per 1000 cu.ft. ought to be about right for a gas engine. Since natural-gas and fuel-oil prices vary, as well as the B.t.u. per cubic foot of gas, we can strike a ratio between them. If A represents the cost of oil in cents per gallon (30 deg. Baumé, 18,000 B.t.u. per lb.)

then the cost per Diesel brake horsepower would be $\frac{8380}{18{,}000} \times \frac{1}{7.3} \times A = 0.0638A$ cents, the value 7.3 being the weight of a gallon of oil of 30 deg. Baumé. If the gas used in the gas engine has a heat value of 1000 B.t.u. per cu.ft., then to equal this cost it must not cost more than $\frac{0.0638A}{8380} \times 1000 \times 1000 = 7.61A$ cents per 1000 cubic feet.

"As a matter of curiosity, just see what you could afford to pay for fuel oil, if your natural gas cost 40c.,

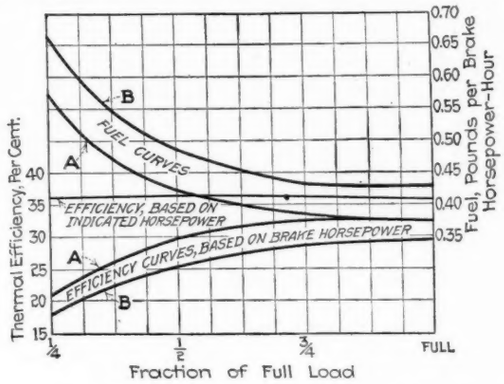


FIG. 2. RESULTS OF TESTS MADE AT FACTORY AND AFTER INSTALLATION

which is quite a common figure in this state. Since the gas runs 800 instead of 1000 B.t.u., we get $40 \times \frac{1000}{800} = 7.61A$, or $A = 6.56$c. per gal. If your fuel is of lower gravity than 30 deg. Baumé, of course you get more pounds per gallon, and naturally you can pay a correspondingly higher price per gallon.

"Consider how impossible it is to think of using illuminating gas with its lower heat capacity and higher price per cubic foot. The serious competitor of the Diesel engine is at present the gas engine using waste blast-furnace gas. In the future, when oil becomes scarcer, the producer-gas engine will again demand consideration.

"If a real successful producer was manufactured that could be operated without the present troubles, the Diesel would have little chance. Such an engine can deliver a brake horsepower on 1¼ lb. of coal. If slack bituminous coal at $2 per ton could be used, the power cost would be less than with a Diesel. If the plan of installing coking plants at the mouth of the mine is ever carried out, the waste-gas engine will then be far the Diesel's superior for electric generation."

"But how about tests on Diesels? I heard you tell one salesman you wouldn't believe in any test."

"I confess I was stringing him, Kelly, but there was just a little truth in my remark, at that. A test doesn't show you by any means what you'll get in everyday operation. Everything is always given the best of care and conditions are practically ideal. It won't do to use test results in figuring on probable yearly operating costs."

Pulling out Fig. 2, Egan continued: "Here are the results of two tests run on a 500-hp. vertical engine. The curves marked *A* are the results of the factory test, while those marked *B* are the results obtained after installation. Mind you, I don't mean that the better values weren't actually obtained. They were, for our man was right on the ground, and I'd gamble that nothing could be pulled off on him.

"The efficiencies and fuel consumptions we obtained are, I believe, about as good as may be expected in any test after installation. The curves all show lower values than those in the factory test, but we must remember that a factory test is made under conditions that cannot be secured in a power plant."

"J. R., I don't understand that curve of thermal efficiency based on indicated horsepower. I always thought the smaller the load the more fuel used per horsepower," Woods ventured.

"That is true, Woods, especially if we are considering brake horsepower. In any engine a certain amount of power is required to overcome internal friction. If this loss is 20 per cent. at full load, there would be 100 friction horsepower in the 500-hp. engine. At half load, or 250 b.hp., the same loss of 100 hp. occurs, and the indicated horsepower is actually 350. Our thermal efficiency per brake horsepower is lower, but per indicated horsepower the efficiency is practically the same as at full load. This is to be expected, since the combustion does not depend on the richness or leanness of a gas mixture. The oil is injected at all times into a volume of excess air."

"Well, J. R., does the friction horsepower include the air-compressor load?" Woods continued in his desire to understand the curves.

"Yes, it does. But in my judgment the air compressor should not be credited to the friction load."

"Why so, Egan?" asked Kelly, who had been silent for an unusual length of time.

"The engine pulls the air compressor, furnishing the injection air. The air, as it blows the oil into the cylinder, helps to keep up the pressure within the cylinder. The indicator card is, as a consequence, of greater area, the expansion line being slightly higher. Then it is

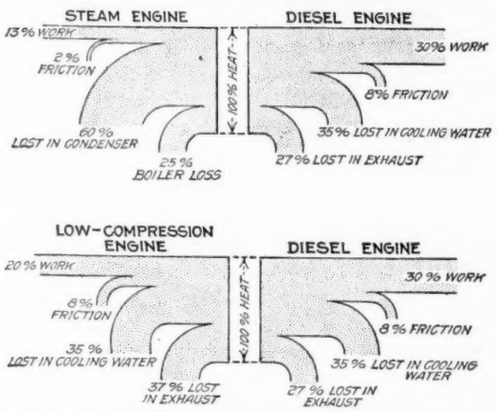


FIG. 3. HEAT DISTRIBUTION IN ENGINES OF DIFFERENT TYPES

my opinion that the engine is getting something for nothing. We increase the indicated horsepower by the use of the air that is produced by the power we call lost. We can arrive at an accurate result as to thermal efficiency by one of two methods: First, we can disregard the indicated-horsepower thermal efficiency and judge our engine by its efficiency based on brake horsepower. A second method would be to figure out the power re-

quired to operate the compressor and to deduct this amount from the indicated horsepower as found by the indicator card, calling the new value 'actual indicated horsepower.' I'll admit this involves an error that could be corrected only by an estimate. It's this: Since part of the air actually is used in atomizing the fuel charge and in overcoming the resistance of the atomizer, this part has no influence on the indicator card. Probably making a fifty-fifty cut on the compressor deduction would be about right.

"Going back to the test we made, Fig. 3 shows the various losses and is the heat balance of the engine. I thought it a good scheme to show alongside of it the heat balance of a condensing steam engine. It's very evident why the Diesel is more economical since it actually uses twice as much of the heat supplied as does the steam engine.

"Since Wood is an ex-hot-ball man, I think the second heat diagram in Fig. 3 will wean him away from his old love. The best of the low-compression engines make use of but 20 per cent. of the heat supplied in the form of fuel and so it's impossible for such an engine to equal a Diesel in performance.

"One thing you boys must observe is the keeping of daily log sheets if you expect to know your operating expenses accurately. To be of value, the log sheet should show hourly readings of the electrical instruments, of the fuel consumed, of the inlet and discharge-water temperatures and of the pressure in the air bottles. In addition, there should be spaces provided for a daily record of the fuel on hand, amount received, amount used during the day's run, and the balance on hand at the end of the day. Similarly, there should be blank spaces for recording the number of quarts or gallons of engine oil, cylinder oil, crank-case oil, gasoline and kerosene used per day, and the number of pounds of waste. And of course there should be space for remarks, which would include reference to any unusual conditions, accidents, repairs, and explanation of extraordinarily high consumption of fuel oil, lubricating oil or other supplies. The size and arrangement of a log sheet will have to be adapted to the equipment of each particular plant, but a little ingenuity is all that is required.

"Now boys, we have discussed a lot of things about our daily work. I've done most of the talking. I hope you fellows, while doing the listening, have let some of it sink in. I may be wrong, but I think I see some results of our talks, in your work. The one thing every engineer must do to be successful is to think over what he is doing. Investigate the cause of everything that happens and if you are at sea, ask someone else.

"This is the last night I can meet with you for awhile. The planning of the new equipment and laying out of the plant addition will take up most of my evenings for some weeks. However, even though we do discontinue these gatherings, there is no reason why we shouldn't take a few minutes each noon to go over things. It's the Madame's prayer-meeting night, and I'll have to step lively if I get there before they all leave. So, goodnight; and Johnson, keep plenty of oil on that air-compressor crank!"

The Electrical Study Course—Fundamentals of Brake Tests on Motors

Introduces the fundamental conception of power being the rate of doing work, as illustrated by the raising of a weight through a given distance in unit time, and goes on to a development of the fact that under all conditions the power delivered by a pulley is the product of its circumference, speed and the force at its face opposing rotation.

SUPPOSE a belt to be placed over a pulley and a weight be attached to it, as shown in Fig. 1. If the pulley be revolved in the direction of the arrow A, it will have a tendency to lift the weight W, but if the end a of the belt is hanging free, as shown, there will not be sufficient friction between the belt and the pulley to raise the weight off the surface it is resting on, unless it be very small. By attaching a weight less than W to a we could increase the friction between the belt and the pulley sufficiently to cause W to be raised, thereby imposing a load on the pulley that, expressed in foot-pounds per min., would be equal to the difference between the weights multiplied by the distance W is raised in one minute. The weight at a could be dispensed with if the belt were attached to the pulley as shown at b in Fig. 2, in which case there would be no question of slippage. If the distance l were very great, such an arrangement could be used to make an efficiency test on a motor, since the power output could manifestly be readily computed from the weight of W and the distance through which it was raised per minute, while the input could be obtained by measuring the voltage impressed upon the motor and the current taken by it, and multiplying the two together. As previously shown, efficiency $= \frac{\text{output}}{\text{input}}$, so that, having established the output and input simultaneously, we can compute the efficiency for the load on the motor at the time.

It would, however, be impracticable to conduct a test in this manner since the length l would have to be too great. Suppose, for example, that l is 314 ft., that W is 10 lb., that the diameter of the pulley, which we will call D, is 1 ft., and that it makes ten revolutions per minute. In one revolution it would raise W a distance equal to its circumference, and since its diameter is 1 ft., that would be 3.14 ft. Since its speed is 10 r.p.m., the distance through which W would be raised in one minute would be $10 \times 3.14 = 31.4$ ft., and in 10 minutes it would have traveled 314 ft. or the entire distance available. From this it can be seen that no continuous test could be made on the motor, and that if its speed were greater than that assumed, the interval for observations would be reduced. Thus, if the speed were 1000 r.p.m. instead of 10 r.p.m., the interval would be one-hundredth part of what it was, or, $\frac{10}{1000} = 0.01$ minute $= 6$ seconds. Hence, it

is evident that, with even such a considerable depth of more than 300 ft., no test could be run.

Suppose, now, that instead of the arrangement of Fig. 2 we use that shown in Fig. 3. Here we have the same belt as in the former case, fastened in the same manner, but instead of getting a pull of 10 lb. by means of the weight W, we obtain it by pulling on the spring balance c until it registers that force. Assume, now, that, as the pulley revolves slowly, we follow it around as indicated in Figs. 4 to 6, always keeping just enough pull on the balance to make it register 10 lb. continuously. It is evident that under these conditions there would be exactly as much load on the pulley as there was in the case of Fig. 2, since it is revolving at the same speed against the same force; that is, 10 lb. It would have the advantage, on the other hand, of allowing the test to run on uninterruptedly for as long a time as desired, but it in turn would be impracticable owing to the impossibility of following the pulley around accurately while keeping a uniform strain upon the scale, for any length of time. In any event it would be applicable only in the case of very slow speeds, since it would of course be impossible to follow the revolutions of the pulley if it were running at any considerable speed. The point to be noted, however, is, that the power required of a motor driving the pulley would be exactly the same as that necessary to lift the weight of Fig. 2. In that case, the power was 10 lb. $\times$ 31.4 ft. per min., or 314 ft.-lb. per min.

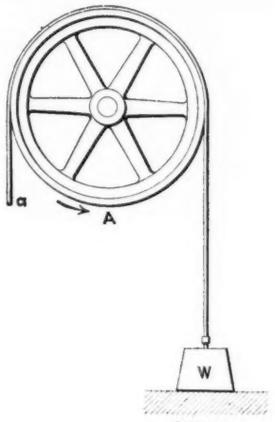


FIG. 1

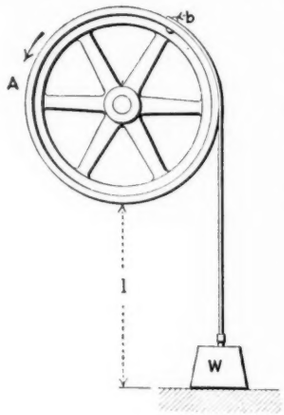


FIG. 2

Since the power developed in the case illustrated in Figs. 3 to 6 is the same, and since the pull is the same, it follows that the distance traveled against the pull is also the same. That is, in making one revolution, pulling against a force of 10 lb., a pulley 1 ft. in diameter would furnish 10 $\times$ 3.14 = 31.4 ft.-lb., and if it is making 10 r.p.m. it would be delivering 10 $\times$ 31.4 = 314 ft.-lb. per min., irrespective of whether it is directly lifting a weight of 10 lb. or only acting against a force of that magnitude imposed in some other way.

In general, we have the following relation: If D be the diameter of the pulley in feet, F the force in pounds acting at its face in opposition to its rotation, S its speed in r.p.m., and P the power it must develop to overcome the opposing force at the speed S, then $P = (\pi \times D \times S) \times F$ foot-pounds per minute. If it is desired to express the output in horsepower we divide by 33,000 ft.-lb. per min., so that if P represents the output in horsepower, we have, $hp. = \frac{\pi \times D \times S \times F.}{33{,}000}$

To overcome the disadvantages of the methods of Figs. 2 and 3 to 6, we can adopt that of Fig. 7, the operation of which will be more readily understood in the light of the theory brought out in what goes before. Fig. 7 represents the same case as Fig. 1 except that a weight is shown attached to the left-hand end of the belt as well as to the right-hand one. Suppose that W_2 is made sufficiently great to cause the friction between the belt and the pulley to reach such a value that W_1 will be raised. Then the actual weight raised would be $W_1 - W_2$, and if the pulley is the same one as shown in Figs. 2 to 6, and is supposed to revolve at the same speed, we would have $P = (\pi \times D \times S) \times F = (3.14 \times 1 \times 10) \times (W_1 - W_2) = 31.4 \times (W_1 - W_2)$. If we assume W_1 to be 30 lb. and W_2 to be 20 lb., we have, $P = 31.4 \times (30 - 20) = 314$ ft.-lb. per min., as in the case of the 10-lb. force in the other cases. This method, employing the actual raising of W_1, would, however, be open to exactly the same objections as were found to apply to the method of Fig. 2, but we can modify the method so as to secure the same result and yet keep W_1 stationary by proceeding as follows:

First, W_2 can be made so small that there is insufficient friction between the pulley and the strap to raise W_1. Then weights can be added to it, causing the

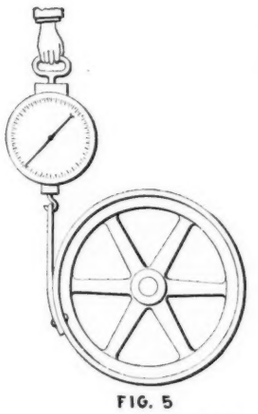


FIG. 5

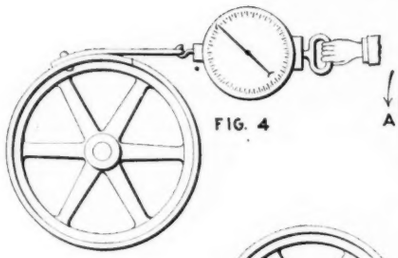


FIG. 4

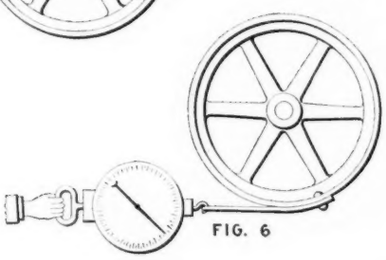


FIG. 6

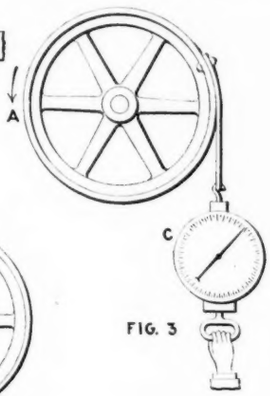


FIG. 3

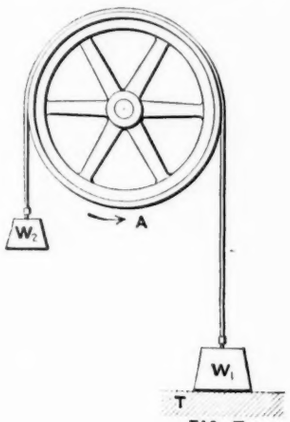
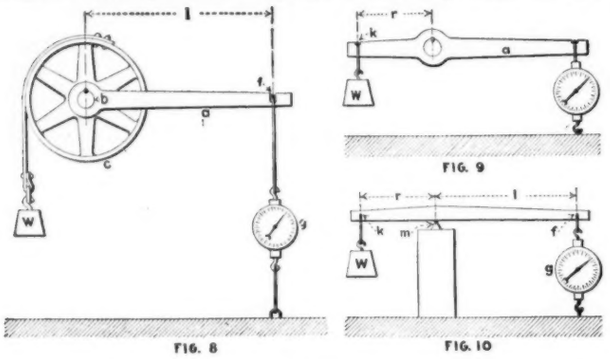


FIG. 7

FIGS. 1 TO 7. ILLUSTRATES PRINCIPLES OF MEASURING THE LOAD ON A MOTOR

pull on W_1 to become greater and greater. Finally a value of W_2 will be reached that will be just barely sufficient to relieve the support T of all the weight of W_1 without actually raising W_1 from it. Suppose that to satisfy these conditions W_1 and W_2 are found to be 25 and 15 lb., respectively. The pulley will then be struggling against a force of $W_1 - W_2 = 25 - 15 = 10$ lb., just the same as if W of Fig. 2 were actually being hoisted, or just the same as if the spring balance of Fig. 3 were trying to hold it back. The power that it develops will therefore be exactly what it was



FIGS. 8 TO 10. PROBLEM IN LEVERS

found to be in the previous cases, if the speed is 10 r.p.m. as before. In this case the retarding force of 10 lb. is due to friction of slippage between the pulley and the strap, whereas in the other cases it was due to work done in raising a weight or dragging around the arm of the person pulling on the spring balance. The difference is that in one case we have slip between a pulley and its belt and in the other we have none. When the latter work is performed, there is nothing to raise the temperature of the pulley, since no energy is consumed at its surface, whereas when the drag on the pulley is occasioned by the friction due to slippage, heat is generated and its temperature is consequently raised.

The method just described can actually be used, although certain modifications are desirable, since it would be a matter of difficulty to make the accurate adjustments of W_2 that would be necessary. Such a modified method will be presented in the next lesson.

The problem of the preceding lesson related to an arrangement such as that shown in Fig. 8. It was required to determine what the weight of W would have to be in order to cause f to pull upward with a force of 10 lb. on the spring balance g, if the diameter of the pulley c were 8 in. and the distance l were 2 ft. This is really a problem in levers. So far as the effect is concerned, the arm a might just as well be prolonged to the left as shown in Fig. 9, and the weight be suspended from it at k at a distance r from the center of the shaft equal to the radius of the pulley. We might represent this arrangement as a lever such as that shown in Fig. 10, in which m is the fulcrum and coincides with the center of the shaft of Fig. 8. A force equal to W pounds is applied at k and a force of 10 lb. thereupon is registered by g. The relation betwen the force at k and that at f depends upon the distances r and l. If we were to keep the distance r unchanged while we shifted f to the right or left, we should find that the force recorded on g would change and that it would become less as we moved away from m and greater as we moved toward it. That is, increasing l decreases the force at f, and vice versa. Also we should find that if l were made the same length as r that the reading of g would be equal to the weight W. That is, if the lever arms are equal, the forces will be equal. Since the force at f decreases when l is increased, it follows that it will be less than W if l is longer than r, and, conversely, that if l is shorter than r the force at f will be greater than W.

As a matter of fact the decrease or increase in the force at f is proportional to the increase or decrease in the distance l. Thus, if l be made twice r we should find the force recorded at g to be one-half the weight of W, or if it were made three times r the force would be one-third of W. So also if l were made one-half of r, the force at f would be twice the weight of W. Putting these statements into the form of a proportion and using F to represent the force at f, we find $W : F :: l : r$, from which we get $W = \frac{Fl}{r}$. It remains only to substitute in this expression the values of F, l and r given in the problem to determine W. The value of F is given as 10 lb. and that of l as 2 ft. Since r is the radius of the pulley, it is half the diameter, which is given as 8 in., making r equal to 4 in. It will be noted that r is given in inches, but that l is given in feet. To compare them they must be reduced to the same units, the simplest way being to express both in inches. We therefore have, $l = 2 \times 12 = 24$ in. and $r = 4$ in. Substituting in the expression for W, we have,

$$W = \frac{Fl}{r} = \frac{10 \times 24}{4} = 60 \text{ pounds.}$$

From the foregoing it is seen that if W weighs 60 lb. the scale g will register 10 pounds.

A 5-hp. motor is being tested by the method indicated in Fig. 7. Its pulley diameter is 8 in. and its speed at full load is 1200 r.p.m. If the weight W_1 is 100 lb., what would the weight of W_2 have to be to impose full load on the motor?

Courtesy, tolerance, and sympathetic understanding constitute the "Three-In-One" lubricant of business life. A man who is courteous may not get along with his associates, because his very coolness, a certain element of veiled sarcasm, or an air of evident superiority, may irritate those about him. He must be *more* than plain courteous. He must be tolerant with that willingness to permit other people to entertain their own ideas, even if they differ from his own. He must be tolerant with that broadmindedness which admits that *his* viewpoint is but one—and there are many others. But he may be courteous and tolerant, and still lack that winning quality so necessary to call out the best in those about us. For this purpose he must possess sympathetic understanding—the ability to appreciate why some people do and do not do certain things; why other people have a right to self interests of their own, and hopes, and ambitions—and fears. Ah, yes! The man who possesses courtesy, and tolerance, and sympathetic understanding, is vaguely described by others as having tact and personality, and as being a good mixer. Stop and analyze the elements of these terms of approval, and you will find that they are not mysterious or difficult. You and I may have them if we will!

EDITORIALS

High Steam Pressures

WHILE enthusiasm has abated, the determination to use higher steam pressures has become more intense. After consideration of other than entropy diagrams, after a survey of what difficulties of materials and operation lie along the road to the goal, engineers are now getting down to "brass tacks" in their efforts to overcome these obstacles. Their slogan is, "The efficiency of our power stations must be increased." And they are just as emphatically confident that the shortest and most efficacious route to this end is by way of high steam pressures.

The limitations of boiler steel are the stumbling blocks in the path. At about seven hundred degrees Fahrenheit the strength of the material seriously lessens. As steel is not an absolutely homogeneous mass but a mixture of crystals and metalloids which even the genius of Hatfield has so far not united in absolute union, and as reduction of the present factor of safety for steam vessels is unthinkable, the boiler problem in the quest for higher steam pressures continues to be a serious one.

Piping to carry pressures far above those now common is available. Welding will do considerable in eliminating leaks and similar troubles. Turbine builders say they are ready to furnish machines for practically any pressure that a boiler may be made to produce. They are waiting for the boiler. Turbines would likely step down the pressure in a comparatively few stages in a rotor of small dimensions. From this point on, the handling of the steam would present no more serious difficulties than are met in large turbines now operating in everyday service.

The economizer in its present form is getting along well under a pressure of two hundred and seventy-five pounds, but one does not want to risk life and property on cast iron for pressures much higher that this. So likely multistage economizers, something after that described in *Power* of April fifteenth, this year, and designed by Sargent and Lundy for the Kansas City power plant, will be used.

At the meeting of the Prime Movers Committee of the National Electric Light Association, held recently at Atlantic City and printed in part elsewhere in this issue, higher steam pressures received hopeful attention. At this meeting Oscar Junggren, turbine designer with the General Electric Company, pointed out that inasmuch as at the low-pressure end of the cycle engineers had reached the practicable limit because of the limitations of condensing water, the only way to increase the temperature range was by raising the higher limit. He discouraged the use of high superheat, urging that the desired total temperature be striven for by increasing the pressure, the aim being to minimize the heat rejected to the condenser. He made the significant statement, too, that for the higher pressures contemplated, "—the turbine probably will look much different than it does today, operating under about two to three hundred pounds." Perhaps he had in mind his colleague, Mr. Emmet's, mercury-vapor power plant, and then maybe he did not.

Richard Rice, of Lynn, who has taken a keen interest in higher steam pressures, urges that the air for combustion be used to reduce the flue gas from the temperatures now common to one hundred and fifty degrees. This with higher pressure will, he believes, increase the thermal efficiency of power plants from the eighteen and nineteen per cent., now good practice, to twenty-five and twenty-eight per cent.

The Daylight-Saving Law

DAYLIGHT saving was again in danger, through the efforts of the Agricultural Committee of the House of Representatives, until the Rules Committee declined to report a special rule giving the daylight-saving repeal parliamentary status as a rider to the Agricultural Appropriation Bill, thus assuring that the law will not be repealed at least during the present summer months. It would be amusing if it were not pathetic to see how many people feel that they have been deprived of some liberty when they are asked to comply with a ruling that may cause them to deviate from the cobweb-covered practices of the past irrespective of the economic value of the change. This is just the condition in many cases today regarding the daylight-saving law. From certain classes we hear complaints of the serious effects of shifting the clock ahead one hour. If these same individuals were kept from sight of a clock for twenty-four hours, they could not guess within an hour of the correct time.

Let each one look at this question from an economic viewpoint and not from any petty imaginary grievance. Is this change in the time economically beneficial? If no other country except our own has shown a disposition to go back to the old and more wasteful schedule, why is it so? In Europe the economic problem is far more serious than in this country; the people are facing a war debt that is staggering, with industries that are restricted or practically destroyed, yet they find daylight saving a good thing economically. In this country, where the effect of the war has been to increase our wealth and build up our industries, is it possible that we wish to keep right on in the old wasteful way?

The economic value of daylight saving is very difficult to estimate. One central-station company operating in a city of 760,000 population estimates that its gross revenue was reduced $350,000 last year due to daylight saving; but its coal bill was also greatly reduced. While this may represent a loss to one industry, it is an economic saving to the country as a whole, in the form of a reduction in electric and gas bills and the conversation of thousands of tons of coal. On the foregoing basis it is fair to assume that the total saving to the country as a whole in electric-lighting cost was not less than twenty-five million dollars, last year, and when the reduction in gas bills is added to this, the total saving is not far from fifty million dollars.

Are the millions who form the great industrial, commercial and professional army of this country to be called upon to pay a tax in increased electric-light and gas bills and have their hours of daylight recreation shortened for all time just to alleviate a grievance, on the part of the farmer, that is at least ninety-five per cent. imaginary, and to satisfy his desire to continue in the practices of antiquity? It might be well for the farmer to remember that his success today is dependent on the vast industrial centers that have grown up in our country and that although those who live in our cities and industrial centers look to him to supply them with a major portion of their sustenance, nevertheless practically everything that he has today to make life pleasant in the rural districts has come to him through our great manufacturing industries. Therefore the proposition is a reciprocal one, and with the farmer on the debtor's side of the ledger. Consequently, the multitudes who live in cities, towns and suburban districts are justified in opposing a tax that amounts to millions of dollars per year and represents an economic waste in the form of increased electric and gas bills, to satisfy the notions of another class. If this law is to be repealed at all, it should be by an act that some Congressman has the moral courage to father. The repeal should not be put over on the public by sneaking it upon the statute books by the back-door method in the form of a rider on some other bill. Let the Calder Act be given a fair trial, and if it is found to be detrimental, then let it be repealed on its merits and not by any camouflage scheme.

Power in Factory Cost Accounting

WITHIN a comparatively few years the importance of cost accounting has gained wide recognition, and it is to be doubted whether there is a progressive manufacturing establishment today that has not installed, or is not at the present time installing, such a system of accounting under the supervision of a competent executive. It is recognized that the value of a cost-accounting system is twofold. It determines actual costs of manufacture and so provides data upon which the sales department can base its quotations, and it is a means of determining where economies can be effected and whether a change in process actually does effect the economy anticipated. To provide the information thus demanded, it is the duty of the accounting department to analyze every detail entering into the cost of the manufactured product from raw material to taxes.

One of these items—and one that perhaps does not always receive the attention that its importance merits—is the cost in dollars and cents represented by the power that is used in the production of a manufactured article. To arrive at such costs is frequently a task of some magnitude, particularly when a factory embraces many departments. Nevertheless, it is requisite that means be provided for ascertaining them.

In such factories as operate an isolated power plant, the first point to be determined is, naturally, the cost of power per unit generated. Most often the power generated must be divided into two general classes, steam power and mechanical power. The former may consist of steam used for the heating of buildings and steam used in processes, such as boiling the contents of kettles or heating drying ovens. The mechanical power may be furnished through the medium of engines or through that of electrical generators or through both. In any event it is incumbent upon the accounting department to segregate the various types of demand and establish the cost rate of each. In this, the engineering department must be looked to to supply accurate operating data, from which the rates can be determined after making due allowances for the overhead charges that apply.

To secure reliable information regarding the operation of a power plant requires the installation of numerous measuring instruments, and it is the duty of every operating engineer who is not provided with them to represent the impossibility, to the accounting department, of accomplishing results without them. Where it happens that the accounting department makes an elaborate analysis of costs of power based upon records that are themselves unreliable, the result is manifestly a mere waste of effort and money to no tangible end. The fact that stands out is, that not only must instruments be provided, but they must be reliable ones. In addition to these, the equipment should comprise standards or semi-standards for the purpose of testing and calibrating the instruments in service. In this connection a regular system of maintenance and periodic testing should be developed and rigidly enforced.

In factories of recent construction the requisite details can and are provided for in the original layout, but often we have to deal with the plant that has grown up from a small beginning and to which additions have been made promiscuously without reference to any general policy of development. Such present the most difficult problem in regard to cost accounting, and require coöperation between the engineering and the accounting departments.

Sectionalizing the Underfeed Stoker

BUILDERS of underfeed stokers of the multiple-retort type have made praiseworthy improvements by providing their machines for sectional drive wherein the total number of retorts are divided into sections of a few or several, depending upon the total number, each section capable of being stopped, started and operated without interference with the operation of other sections.

This improvement will give a flexibility of movement of incoming coal and fuel bed to accomplish results which even highly skilled operators find it difficult to attain with a stoker the retorts of which are not sectionalized. In some recent installations consisting of thirteen-retort stokers, the stokers are in four sections each, each section driven by its own motor. Another installation of seven-retort stokers has each stoker divided into two sections. In the United States Nitrate Plant Number Two, described in the March Twenty-fifth issue, the fifteen-retort stokers are divided into five groups of three retorts each, one adjustable-speed motor driving each stoker, any one of the five groups of retorts being thrown in or out of motion by use of clutches.

One company is dividing its seven-retort stokers into three sections each, and has developed two methods of driving them. In one drive three four-speed motors are used; in the other, one four-speed motor with three two- speed power boxes.

The improvements are among the many developed to reduce the errors and shortcomings of the human element by making it easier to do the right thing than the wrong thing.

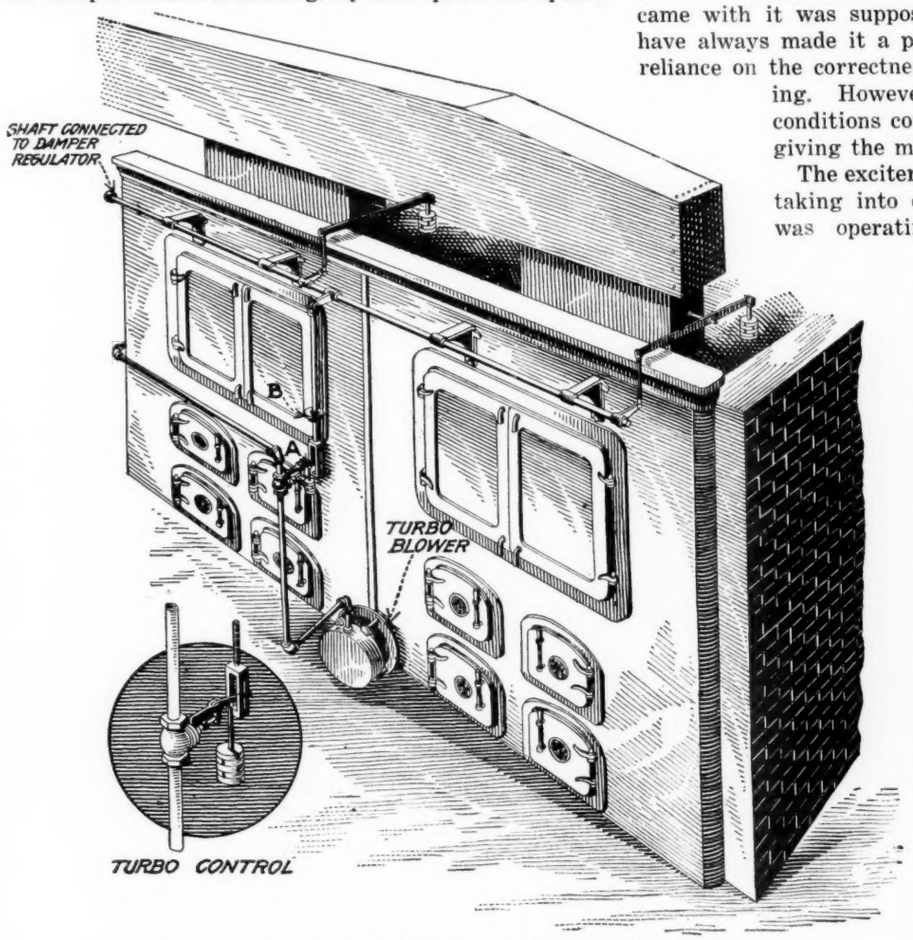
Correspondence

Damper and Blower Control

It was my pleasure some time ago to visit a small steam plant in which a turbo-blower was installed midway between two 6-ft. diameter horizontal boiler fronts. A steam damper regulator had controlled the draft through the medium of a horizontal shaft bracketed to the fronts of the boilers and connecting with the uptake dampers. The control of the turbo-blower was also taken from this shaft, as shown in the illustration.

Two clevises were introduced between the bell-crank lever on the steam-control valve to the turbo-blower and the lever on the shaft. Lost motion was introduced into the clevis on the bell crank *A*. There was also an adjustment *B* in the rod to lengthen or shorten it. The method of operation was excellent.

When the pressure dropped about one-half pound, the damper shaft turned slightly and opend the uptake dampers just a trifle. The next half pound opened the uptake dampers perhaps halfway and started the blower. When closing, the blower was shut off first and then the damper was shut practically tight.



DAMPERS AND TURBO-BLOWERS GOVERNED FROM SAME SHAFT

When the load was from 75 to 100 per cent. of the boiler capacity, the blower was in operation practically all the time, but on a light load the reverse was the condition. By means of the handwheel adjustment a balanced draft would almost obtain. As an upward motion opened the dampers, by pulling down on a hand chain the damper was closed on either boiler.

All in all this was, in my opinion, a very efficiently operated control. The engineer said that the control valve for the turbo-blower came with straight lever, but that it didn't seem to fit in his calculations, so he made a new lever of the bell-crank variety.

Waltham, Mass. C. W. PETERS.

Exciter Difficulties

Recently, I put into service an exciter that developed very peculiar characteristics. This machine was purchased second-hand and the auxiliary equipment that came with it was supposed to be correct, although I have always made it a practice not to place too much reliance on the correctness of equipment without testing. However, in this case the operating conditions could not be determined without giving the machine a trial.

The exciter gave very satisfactory results, taking into consideration the fact that it was operating under severe conditions, being in parallel with three other machines of different design and manufacture, one a four-pole interpole unit, one a two-pole interpole type and one a four-pole noncommutating-pole machine. The field rheostat was very sensitive, and the slightest movement of the handle to increase or decrease the field strength produced very broad results, a minimum variation of about 20 per cent. full load. An investigation followed and it was found that the rheostat was of the two-unit type, both units connected in series with the shaft operating both arms at once, thus cutting in or out twice the resistance between each contact, causing abrupt changes in the regulation of the load. This operation was equivalant to operating two independent rheostats at once. Future trouble was eliminated by making the field-current adjustments with one section of the rheostat only; the other section of the rheostat was connected in the field circuit permanently as a constant fixed resistance.

J. W. TRUESDELL.

Parlin, N. J.

Neglected Cooling Towers and Cooling Ponds

Now is the proper time to give attention to cooling towers and cooling ponds, making all necessary repairs, changes or additions, so that the maximum cooling can be realized during the hot weather.

It is surprising how some of the larger installations are allowed to go to rack and ruin. In one instance the cooling towers were inefficient due to the following causes: Water unequally divided among five towers, where two towers received too much water and the other three received too little. The towers receiving an excess amount caused the water to enter the distributing boxes with such velocity that it splashed out at the points of discharge, which robbed certain areas of water.

Troughs leading to the V-notch pans were in many instances either out of place or knocked off, thus causing a large portion of the pans to be dry and large areas of the tower to be useless. Furthermore, the V-notch pans were not level, and this caused the water to flow to one side of the tower only, the other side being completely dry.

In the case of the V-notch pans out of place, the water ran in an unbroken stream to the bottom of the tower without being cooled. It was supposed to drop on board checkerwork or boards arranged vertically so as to form a film of water on their surfaces. Forced-draft fans at the bottom blew air up through these surfaces and cooled the water when properly distributed.

Another trouble was that the forced-draft fans operated too slowly on damp days and too fast on dry days. They did not take into consideration that most (one authority says 90 per cent.) of the cooling is due to evaporation of the water cooled, hence on cloudy, humid days the fans should be operated at maximum speed, and on clear dry days they need not be run nearly so fast.

Hot bearings, due to flexible couplings being in bad repair, caused certain fans to be shut down for periods of 10 to 12 hours out of the 24. Belt slippage caused when the attendant allowed water in the bottom reservoir to get so high that it overflowed into the fan housing and the blades threw it on the belt. The water also broke the fan blades, compelling a shutdown and repair expenses.

So little intelligence was exercised in the operation of these towers that the fans were actually run faster at night than during the day, and they were usually not speeded up in the mornings until 9 or 10 o'clock, when the injection temperature of the water rose so high that the vacuum dropped 1½ to 2 in. on the 8000-kw. turbine. On many days the operation was so bad that the vacuum dropped as much as 4 inches.

The attendants often went home without the shift chief's knowledge. In fact, the job was so soft that one man was found to be holding down an 8-hour shift in another plant. Five repairmen spent a great deal of time on the cooling towers resting, shooting crap and matching coins—charging all this time against the cooling towers and the power plant.

The remedy for most of this inefficiency would have been the employment of an expert engineer to look after this operation, also the use of such recording thermometers as would enable him to keep a tab on the various towers.

The cooling pond was inefficient due to the following causes: The spray nozzles were partly clogged with chips, etc., and insufficient spray nozzles made it necessary to maintain pressures varying from 12 to 17 lb. Furthermore, the nozzles were too large (2½-in.) and better results would have been obtained if 2-in. nozzles had been used. They were set too close to the water and better cooling would have been secured if the sprays had been elevated. Another fault was that the spray pond was located in a hollow, whereas cooling of water is decidedly easier when the pond is exposed on all sides to the winds. Screens to the suction well were not properly designed so as to make it possible to remove all accumulations of sticks, leaves and other rubbish.

A spray pond is generally not subject to misoperation to the extent that a cooling tower installation is, however, I might mention that the cooling towers held the injection temperature from 2 to 6 deg. lower on warm, humid days than the spray pond. Under normal conditions the cooling towers required approximately 300 hp. to drive the forced-draft fans. The discharge head of the circulating pump was also nearly ten feet greater in the cooling-tower installation.

Franklin, Ohio. WALDO WEAVER.

Wrong Connections to Slip Rings Caused Reversed Rotation

The direction in which a rotary converter will turn, when starting from the alternating-current end, depends on the direction of rotation of the magnetic field that starts it. This in turn depends on the order of applying the polyphase voltage to the armature, just as the direction of rotation of an induction motor depends on the order in which the supply wires are connected to the stator terminals. In either case the direction of rotation can be reversed by the interchanging of two of the supply wires.

A certain synchronous converter had been in operation so long that the collector rings had worn too thin to be safe, so it was decided to replace them. The new rings were furnished by the manufacturer of the converter, but were installed by the operator. On the first occasion of starting the machine, the rotor started in the wrong direction. As no connections had been disturbed except the internal ones to the rings, the trouble was properly attributed to the armature leads having been replaced in the wrong order to the rings.

Ordinarily, such a mistake is unlikely to happen, because completed leads are of such a length that the terminals of each will just reach the rings to which they should be connected. In this particular instance, however, new leads had to be made and installed, and the man who removed the old leads had to leave the job without completing it. It was necessary for his successor to make a guess, and the guess proved to be a wrong one.

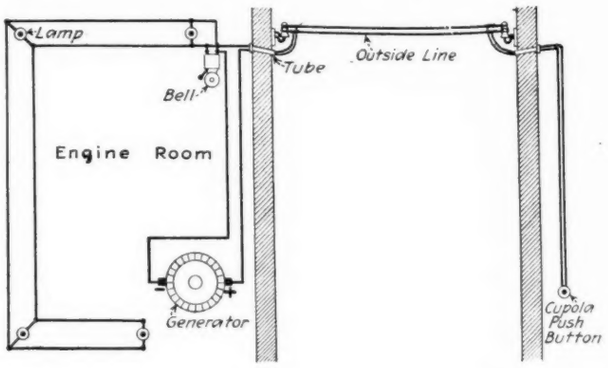
Fortunately, however, two of the armature leads were long enough to reach the farthest ring and their interchanging restored normal rotation. This is only another instance that goes to show the necessity of carefully marking all connections, when they are disconnected, so that anyone who may be called in to complete the job will not have to guess where the connections should be made. This in many cases will save not only unnecessary delays but often considerable expense.

Brooklyn, N. Y. E. C. PARHAM.

A Reliable Signal System

The transmission of signals for air from a foundry cupola to the engine room, where the blowers are often located, is attended with more or less delay, to say nothing of occasional misunderstandings that call for explanation. In many plants the foundry cupola is at a considerable distance from the engine room, which also complicates matters.

In a power plant that consists of a 350-hp. Corliss engine and a 25-hp. engine both direct-connected to blowers and attended by the same engineer, there was



WIRING DIAGRAM FOR SIGNAL SYSTEM

also an air compressor and two electric generators, all contributing to the noise that made it difficult to receive signals either by a gong or telephone. A reliable and flexible signal system was installed by using the following arrangement:

Near the cupola was placed one of the best push-buttons made, with good heavy contacts, so that the signals could be given with certainty. Around the cupola, where the wire was subjected to comparatively high temperatures, slow-burning insulated No. 14 wire was used; beyond this and across the yard weatherproof insulated No. 14. The wiring was installed as securely as for any lighting circuit, the joints soldered and properly taped, tubes placed in the walls and the whole system well insulated. This arrangement has practically eliminated all troubles. Where the line would be exposed to ice and snow, it would be good policy to use a No. 10 wire across the yard. Plenty of copper is a good feature, as it keeps downs the volts drop in the line.

In the engine room the line was connected through a 10-in. fire-alarm type of gong to a 15-volt direct-current generator. Where a generator is not available a storage battery can be used. The circuit was run to various points in the engine room and small receptacles installed, in which were placed low-voltage red lamps, so that if the engineer did not hear the gong he would see the lamps and know the gong was ringing. A diagram of the installation is shown in the illustration. This arrangement places all lamps and the gong in parallel but in series with the push-button, which must have good contacts to carry the necessary amperage at low voltage.

Thus, when the cupola button is pushed the gong rings and the lamps blink the signal, and even if the engineer is in a far corner of the engine room he can catch the signal without listening for the gong. If a battery is used for power supply, the best arrangement is a 4- or 5-ampere storage battery so connected to a direct-current generator that weekly charging is possible.

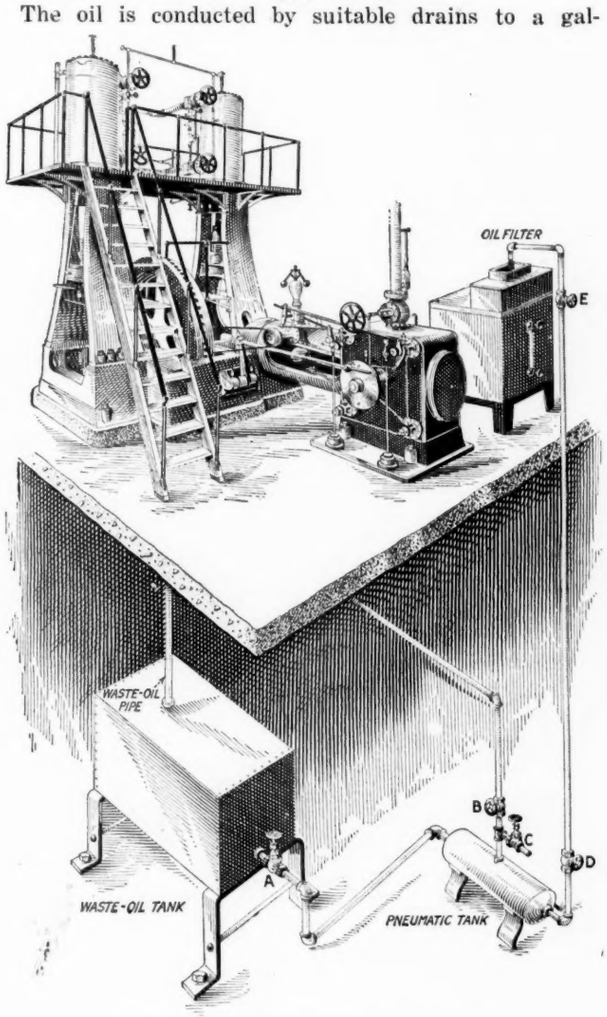
This system was installed to help an engineer who was hard of hearing and got into many disputes over the air signals, but his successor also pronounced the scheme "a good thing." H. S. RICH.

Hartford, Conn.

Oil Handled by Air Pressure

The illustration shows an easy and cleanly means of handling the otherwise waste oil from engines and other machines. It was installed by the writer and handles all the oil from four engines and two refrigerating machines at the plant. All the material used was found around the plant, the only outlay being for labor and most of that was "spare time."

The oil is conducted by suitable drains to a gal-



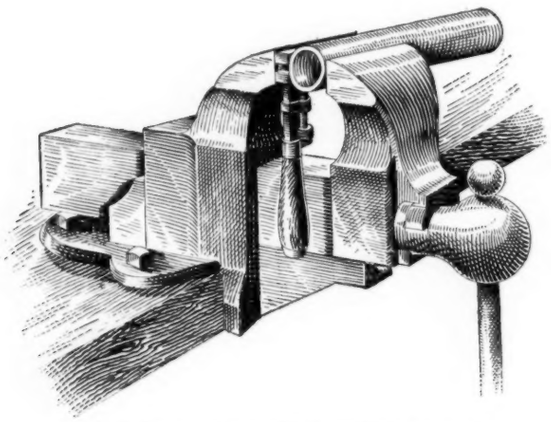
PIPING OF OIL-HANDLING SYSTEM

vanized-iron tank in the basement, from which it is drawn through the valve *A* into the pneumatic tank, which is a 15-gal. heating boiler. The valve *C* is left open to vent the air during the filling processes. After the pneumatic tank is filled, valves *A* and *C* are closed and *B* and *D* opened, air from the compressed-air system being admitted at *B*. By means of the valve *E* the operator regulates the flow of oil to suit the capacity of the filter. C. J. DOMVILLE.

Port Hawkesburg, N. S.

Holding Pipe in a Vise

A handy way of holding a pipe or other piece of round material in an ordinary bench vise is by the use of a common monkey wrench. The wrench when inserted in the vise and adjusted to fit the piece to be held will



HOW PIPE CAN BE HELD TIGHT IN VISE

grip it with a force that will resist any turning effort while it is being worked upon. The method of applying the wrench is shown in the illustration.

Guantanamo, Cuba. W. W. PARKER.

Value of Station Records

The most valuable records of power-plant operation that can be kept are the daily records of coal burned, steam evaporated and used and kilowatt-hours generated. These figures, properly recorded and analyzed, will show up the weak points in the operation of the equipment and suggest the remedies.

When the engineer in charge of the station knows that he burned 3 lb. of coal for every kilowatt-hour generated one month, and 3.5 lb. of coal for every kilowatt-hour generated the next month, he may be able to account for that difference in efficiency to his own satisfaction by saying that there must be a difference in the quality of coal burned or that the boilers needed cleaning. But the fact remains that there has been a whole month of performance that was not the best that could be expected of the equipment.

Suppose now that the engineer in question had been in a position to keep daily records of coal burned as well as the kilowatt-hours generated and had watched these figures day by day. He would then have detected the rising coal rate as soon as it appeared and would have been warned to look for the trouble. If there had been no change in the coal supply, it would be evident that the trouble was in the performance of the equipment and he would have to proceed by a process of elimination to hunt out the faulty spot.

Of course the first step would be to try to find out whether the trouble was in the boiler room or in the turbine room. For this the engineer would turn to his record of steam evaporated and see whether the pounds of steam per pound of coal had fallen off any. If not, it would be safe to infer that the trouble was not in the boiler room. If there were no flow meters on the boilers he would have to depend on the feed-water meter for the amount of steam evaporated.

Having traced the trouble to the turbine room, the next step would be to locate the faulty unit. This would be facilitated by having a flow meter on each generating unit. If he found no increased steam rates on the generating units he would have to hunt through the auxiliary equipment for the loss. Thus, the more carefully the engineer kept the records on the operation of his equipment the more surely and quickly he could locate the loss in efficiency.

Now suppose that the steam evaporated per pound of coal burned had shown a substantial decrease. Then it would have been certain that the trouble was in the boiler room. We will assume that the engineer has had samples of coal tested from time to time and knows that he is burning as good a grade of coal as usual. Then he will have to decide that one or more of the boilers is at fault. But which one? Here, again, a flow meter on each unit will simplify the problem by pointing out which unit has fallen off in evaporation rate.

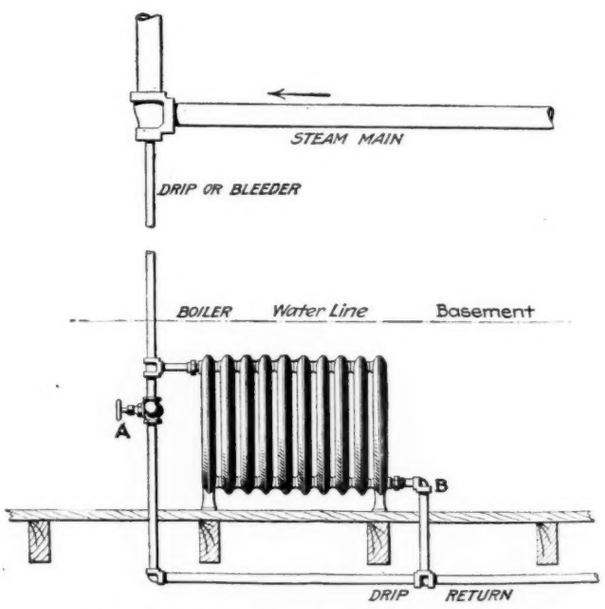
In every case when the faulty unit has been located, it can be cut out at once and put into good operating condition with a minimum of delay. If the facilities are available for testing samples of coal burned daily, complete records of the thermal efficiency of the plant may be kept.

C. C. RAITT.

Dayton, Ohio.

Radiator Heated from Main Drip

On page 325 of the Mar. 4 issue of *Power*, W. T. Meinzer describes how to heat a radiator located below the vacuum return main. The accompanying sketch shows how some heat can be secured from a radiator located in a cellar or basement below the boiler water line on a low-pressure, gravity-return, steam-heating



RADIATOR BELOW BOILER WATER LEVEL

system. By closing the valve *A* all the water of condensation from the steam main will pass through the radiator. If a check valve is placed on the radiator outlet at *B*, any possible chance of a "come back" is prevented.

If it should be necessary to have the radiator cold at times, this will occur when the valve *A* is opened.

Kingston, Ont., Canada. JAMES E. NOBLE.

Inquiries of General Interest

Valve Cutting from Lack of Lubrication.—What effect would it have on the steam valves and valve seats of a tandem air compressor, with 7- and 14-in. compound steam cylinders, using the compressor by admitting live steam through a bypass to the low-pressure cylinder? J. C. R.

A bypass to the low-pressure cylinder is usually intended only for warming up and starting, and if lubrication is not provided during extensive use of the bypass for operating the compressor, the valves and valve seats are likely to become cut.

Slower Cooking in Trapped Steam-Jacketed Kettles—Why should the same amount of cooking in our steam-jacketed kettles require about twice as much time when the discharge of condensate is controlled by traps as when the kettles are supplied with steam of the same pressure and the condensate is discharged by an open bypass? P. E. N.

When the traps are used there is less active circulation of the steam and slower absorption of heat by the heating surfaces of the kettles, mainly on account of air pockets formed in the steam spaces of the kettles, which are more thoroughly swept out when the flow of steam is continuous.

Weight of Compressed Air—What is the weight of 24 cu.ft. of dry air at a temperature of 125 deg. F. under a pressure of 26 lb. per sq.in. gage? E. C.

At atmospheric pressure, or 14.696 lb. per sq.in. absolute, a pound of dry air at 32 deg. F., or an absolute temperature of 460 + 32 = 492 deg., has a volume of 12.387 cu.ft.; and as the density is inversely as the absolute temperature and directly as the absolute pressure, the weight of 12 cu.ft. of air at the temperature of 125 deg. F., or 460 + 125 = 585 deg. F., and pressure of 26 lb. per sq.in. gage, or 26 + 14.696 = 40.696 lb. per sq.in. absolute, would be

$$\frac{492 \times 40.696 \times 24}{585 \times 14.696 \times 12.387} = 74 \text{ lb.}$$

Piston Clearance and Clearance Volume—What is meant by clearance of an engine? W. R. G.

The term clearance is used in two senses. It may refer to the distance the piston could be separately moved beyond its position at the end of the stroke before it would come in contact with the head of the cylinder, or the term may be used with reference to the volume of space in the end of the cylinder and connected passages, from the piston to the valves, when the piston is at the end of its stroke. To avoid confusion the former is called "piston clearance" and is always a lineal measurement, and the latter is termed simply "clearance" and the amount generally is quoted as a percentage of the volume swept through by one stroke of the piston.

Factor of Evaporation Generating Superheated Steam.—What is the factor of evaporation when, under actual conditions, a boiler generates steam at 200 lb. gage with 100 deg. superheat from feed water at 212 deg. F.; and how many pounds of water have to be evaporated per boiler horsepower? J. J. R.

An absolute pressure of 200 lb. gage would be equal to 215 lb. per sq.in. absolute, and, according to the steam tables, a pound of steam at that pressure, superheated 100 deg. F., contains 1259 B.t.u. above 32 deg. F., so that if the feed water temperature is 212 deg. F., each pound of feed water for conversion into steam of the stated pressure and quality must receive 1259 + 32 — 212 = 1079 B.t.u. Unless otherwise provided, a combined boiler and superheater should be treated as one unit and the equivalent of the work done by the superheater should be included in the evaporative work of the boiler. Evaporation of a pound of water from and at 212 deg. F. requires 970.4 B.t.u., and therefore, under the actual conditions, the factor of evaporation would be 1079 ÷ 970.4 = 1.111; and as a boiler horsepower is equivalent to the evaporation of 34.5 lb. of water from and at 212 deg. F. per hour, under the conditions stated a boiler horsepower would require evaporation of 34.5 ÷ 1.111 = 31.05 lb. of water per hour.

Primary and Secondary of Transformers—Is the high-voltage winding of a potential transformer always considered the primary? If a transformer is designed to step 2300-volt alternating current down to 115, and it is connected to step 115-volt current up to 2300 volts, which winding will be the primary? M. A. B.

The winding of a transformer which is connected to the source of power is the primary, and the winding connected to the load is the secondary. When the transformer referred to in the question is connected to step from 2300 down to 115 volts, the 2300-volt winding is the primary. When it is connected to step from 115 up to 2300 volts, the 115-volt winding is the primary and the 2300-volt winding the secondary.

Effectiveness of Small Economizer.—To what temperature could water at 60 deg. F. be heated in its passage once in 12 minutes, through a pipe-coil economizer containing 200 lineal feet of 1¼-in. iron pipe placed in a boiler smoke flue in which the uptake gases have a temperature of 600 deg. F.? E. C. A.

There would be 87 sq.ft. of pipe surface for heating about 78 gallons of water per hour. The rate of heat transfer would depend on the arrangement of the pipe surface in the path of the flue gases, the volume of the heated gases and the manner in which they are swept over the pipe surfaces, and the freedom of the surfaces from soot and scale. If the coil is made in the form of a stack of pipes, placed in the smoke flue approximately at right angles to the direction of flow of the gases, and the pipe surfaces are kept as free of soot and scale as it is customary to maintain boiler-heating surface in good practice, and there is sufficient flue gases to retain a temperature of not less than 500 deg. F. after passing across the coil, it is estimated that the water could be heated to about 300 deg. F.

Current Taken by Induction Motor—How is the current taken by an induction motor calculated? I have a 25-hp. three-phase 60-cycle 220-volt induction motor and would like to know how to figure the full-load current. V. K. S.

The current per terminal taken by an induction motor usually can be found on the name-plate of the machine. Formulas that give values close enough for practical purposes are: For single-phase motors the full-load current per terminal is: amperes $= \frac{\text{horsepower} \times 1000}{\text{volts}}$; for 4-wire, two-phase motors, amperes per terminal $= \frac{\text{horsepower} \times 1000}{\text{volts} \times 2}$; for 3-wire operation the current in the outside wires is the same as for a 4-wire circuit, but the current in the center leg is equal to the outside-leg amperes times 1.414. For a three-phase motor the amperes per terminal $= \frac{\text{horsepower} \times 1000}{\text{volts} \times 1.732}$, or in your problem equals $\frac{25 \times 1000}{220 \times 1.732} = 65.6$ amperes.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

High Steam Pressures*

REPORTS of the Prime Movers Committee presented at the conventions held in 1916 and 1917 gave a brief comprehensive outline of the possible economies to be obtained by going to the so-called higher steam pressures, the principal difficulties to be encountered and a statement on this subject from some of the leading manufacturers of boilers and turbines. Since then, little actual progress has been made, chiefly because the thoughts and energy of everyone have been devoted to winning the war.

The project is by no means dead, and during the interval the Buffalo General Electric Co. has placed in service a plant designed to be operated at 275 lb. boiler pressure and 275 deg. superheat, giving a total temperature of 689 deg. F. The Public Service Co. of Northern Illinois has installed and is operating a plant with a boiler pressure of 315 lb., and 225 deg. F. superheat, giving a total temperature of 651 deg. F.; the British Thomson-Houston Co. has had in operation in its works at Rugby, England, a small boiler plant operated at about 350 lb. pressure and with such superheat that the total temperature ranges from 700 deg. F. to 750 deg. F. at the boiler.

While minor troubles have been encountered at all these installations, such as might be anticipated when the pressure and temperature of the steam system are increased, the committee is advised that in each instance the installation is considered generally satisfactory.

There have been practically no troubles with the boiler or turbines, due to the changed steam conditions. Flange joints in the steam piping lines and under the bonnets in the gate valves proved more troublesome to install and maintain. The small valves, gage-cocks and like apparatus, which usually are more troublesome to maintain than the larger apparatus, have required much more attention. Minute blow-holes in valve bodies, fittings, etc., which would not be expected to give trouble on lower pressures, have shown troublesome leaks on the higher pressures. These should be expected and are usually corrected as soon as there is sufficient demand on the manufacturers to justify developing apparatus for the new conditions.

These installations, however, are but a step in the direction that it is possible to go, and in analyzing these possibilities it is first necessary to see what are the limits and then the possibilities of approaching these limits. The first limit is undoubtedly the boiler. The Babcock & Wilcox Co. advises the committee that the statement submitted by the committee in the 1916 report covers the situation today and that it has nothing further to add at this time. The company states that the intervening war period has much interfered with its experimental work, and although these experiments have been continued they necessarily have been made under adverse conditions, and nothing further can be added at this time on the possibility of building boilers for pressures higher than 300 to 350 pounds.

While it may be possible to increase the boiler pressure to almost any desired point by changing design, there is today a definite limit to the maximum temperature which it is safe to use. That is fixed by the steels now in commercial use and appears to be between 600 and 700 deg. F. This is brought out by the following statement made by Charles L. Huston, vice president and works manager of the Lukens Steel Company:

> While we do not have records to indicate the service qualities of steel at temperatures higher than those at present in use, I believe I could say with a good deal of confidence that the use of soft carbon steel, say 50,000 lb. to 60,000 lb. tensile strength, would be thoroughly safe up to temperatures of, say, 600 deg. F. or under the critical temperature of steel, which varies little between soft and medium hard steels.
>
> I do not believe that the use of higher tensile-strength steel in standard carbon steels would be desirable, for the reason that as the critical point in steel, say about 700 deg. F., is approached the metal becomes less ductile and would be more likely to crack.

In the above statement I am expressing my opinion simply in regard to standard carbon steels and not touching upon alloy steels, the behavior of which at these high temperatures I am not familiar with, nor do I know of any experiments of similar character that have been made in recent years on such steels.

From the fact, however, that these old experiments (made by Dr. Huston and his father in 1876—"Journal," Franklin Institute, 1878) showed similar characteristics with chrome steel as compared with carbon steel I have been led to infer that the same conclusions might be applied generally to all classes of steel, viz. that when you get up into higher temperatures it is desirable to keep soft, ductile material.

Many people regard a piece of steel as an absolutely homogeneous mass of metal, whereas all steels consist of a mixture of ferrite crystals with various metalloids, usually carbide of iron, phosphide of iron and sulphide of iron, interlarded between the ferrite crystals, the ferrite having the highest melting point in the combination and the different metalloids requiring different degrees of temperature to fuse them. The greater the variety of metalloids, introduced into the steel, the greater is the need of ascertaining the fusing point of these different metalloids, for the reason that when the steel is heated to a temperature where the weakest metalloid is either fused or its structure broken down by the heat, the strength or ductility of the whole mass is more or less impaired.

Therefore, I should incline to think that unless very elaborate experiments have been made and service tests obtained from any theoretical alloy steel that might be thought advantageous to use it would be safer in the meantime to stick to soft steel of straight carbon quality, which carries the largest proportion of pure ferrite in its make-up.

The attitude of the Allis-Chalmers Co. on the turbine end is clearly explained in the following quotation from its letter:

> We would advise that our standard high-pressure condensing steam-turbine apparatus is designed for working steam pressure as high as 200 lb. gage for the smaller machine and 250 lb. gage for the larger ones. Therefore, for pressures of 300 lb. gage and above some special development would be involved in each case. We find that our standard line of apparatus is suitable for practically all of the inquiries we receive, and as pressures above 250 lb. gage would apply entirely to the larger units, the development to meet such pressures would not be excessive, as it is our practice to blade the larger machines for as near to actual operating conditions as our manufacturing standards will permit.
>
> For temperatures above about 500 deg. F., we use a partial cast steel up to about 650 deg. F., above which temperature we have steel cylinder construction which we feel is suitable for maximum temperatures.
>
> We do not find much tendency in this country to go above normal operating temperature of about 600 deg. F. except in very extreme cases for large units and, with this temperature, steam pressures of 300 lb. gage or 350 lb. gage do not offer any difficulties or involve any considerable special development expenses.

The General Electric Co. makes the following statement:

> Turbines suitable for higher pressures can without question be produced without involving us in any complications by the time that boilers can be furnished for said purpose. It would appear that this matter is essentially a boiler problem. We can supply the turbines for you, if you can obtain the boilers.

A full discussion of the possibilities appeared in the paper by Eskil Berg on "Advantages of Higher Pressure and Superheat as Affecting Steam Plant Efficiency," which was published in the *General Electric Review* of March, 1918.

The position of the Westinghouse Electric and Manufacturing Co. is clearly stated in the following quotations from its letters:

> We look with favor upon the gradual upward tendency in steam pressures, but with moderation on the total temperature. In other words, speaking from the standpoint of the turbine alone, if the central station were ready with its piping and fittings and with its operating knowledge to use pressures of 300 lb. and above, we would say that we are ready with the turbine, and we would approve of the step being taken. With our present knowledge of power-plant efficiencies it seems as though any future

*From Report of Prime Movers Committee and Discussion, National Electric Light Association's Convention, 1919.

material improvement must lie in that direction. We think your committee can well assume that the turbine is not or should not be one of your problems. We think perhaps that the practice will have to start with the large central stations. It will be a manufacturing handicap if we have to build both high-pressure and moderate-pressure machines. However, between the operators and the manufacturers it should always be possible to find feasible methods of doing anything that is sound and economically desirable.

We wish to state that the effect of the higher steam pressure is to add materially to the cycle. The efficiency of the turbine will become less because of the smaller volume and greater density of the steam at the high-pressure end, and because of the greater quantity of moisture at the exhaust end.

To date no turbines have been built adaptable for pressures beyond 300 lb. Some few are being built by this company for this pressure. For pressures higher than 300 lb. newly designed turbines will be required. There will not necessarily be any change in type, but merely additional elements to handle economically the added pressure range. Of course steam chests and controlling valves represent some difficulty in design, but these seem to be by no means insurmountable. In this connection it should be noted that the valves will not be materially less in size because of the smaller volume of the steam. If the steam velocity in the valves and piping were made inversely proportional to the density, the valves and piping would remain the same size.

We think the question as to what extent this company is prepared to go in furnishing turbines built for steam pressures higher than 300 lb. is as much a commercial consideration as one of engineering, considering the development costs involved. There is no doubt that turbines can be built for these higher pressures, and there will be gains in economy due to this, such as above outlined. I would say that if we attempt to design turbines for these higher pressures, we would prefer this to be brought about by an increase of pressure without material increase of temperature; that is to say, we would prefer a reduction in the superheat; for instance, 500 lb. pressure with a superheat that would give a total temperature not to exceed 650 deg., that is, about 170 deg. superheat.

Apparently the manufacturers of steam turbines favor the movement toward higher pressures and are prepared to meet it, while manufacturers of boilers require time for further investigation and development work before they go much above the existing limit, which is around 350 lb. The economizer situation is less satisfactory; the limit of pressure appears to have been reached with the standard cast-iron economizer now in use. To go beyond this point would require either an entirely new type of economizer, or an installation of the present type operated at a pressure much below that of the boiler, which would require running boiler-feed pumps in series.

Little attention appears to have been given to adapting to higher steam pressures the various steam auxiliaries required in the installation. While these units are comparatively small in size, they are numerous and require proportionately more attention from the operating force than the larger units. It is just as important to avoid trouble with them as it is with the main prime mover. Your committee is also unable to learn that manufacturers of valves, fittings and other steam appurtenances of the power plant have given any special thought toward adapting their apparatus for pressures much above those now common. It would, therefore, seem that there is much further development work to be done before a successful installation of pressures above those now in common use can readily be made. Probably the initiative will have to come from the users, and when there is sufficient demand for improvements in the existing construction, the manufacturers will respond as readily and as successfully as they have in the past.

Another factor which has a bearing on this project is the position that the boiler-insurance companies may take. Statements have been obtained from some of the leading companies.

One company states:

We are pleased to advise you that the pressure for which the safety valves on steam boilers are set has no bearing on the rates charged for steam-boiler insurance. Steam-boiler insuring companies require that steam boilers be so constructed and operated that they shall have a computed factor of safety of at least five on the pressure carried. Some companies will not reject a risk unless the factor of safety is less than four; but I believe no boiler-insuring company will carry a boiler risk when the computed safety is less than four. You probably know that the Boiler Code of the American Society of Mechanical Engineers requires that all new boilers be constructed so as to have a factor of safety of at least five.

With boiler-insuring companies a steam boiler is either safe or unsafe. If it is unsafe, there is no amount of premium that any insurance company will accept to carry the risk. If it is safe, then the premium is the same whether the safety valve be set for 225 or 450 lb. per sq.in. providing there is a computed factor of safety of five.

Another company writes:

We wish to advise you that the rate of insurance on a boiler carrying 300 lb. pressure or more would depend upon the amount of the liability, or in other words the amount required by the assured. Further, we would advise that the rates for steam-boiler insurance are standardized. All companies are required to give the same amount of premium for the same amount of insurance; the amount required can be readily determined on application for a specified amount of coverage.

It would appear from the above that the companies insuring boilers would not decline to write insurance on a boiler operated at any pressure within the limits herein discussed, provided said boiler had a proper factor of safety.

If steam plants are to increase their pressure materially, the wise procedure would be to do so gradually, or in steps of moderate increases each. By this method, troubles and losses would be minimized and the experience with one installation would help solve the problems for the next increase.

The coal consumption of this country is increasing at a rapid rate, the cost of fuel is steadily rising and the total supply of good steam coal has a definite limit; therefore, it is the duty of the engineer to consider all practical methods to conserve this source of power and to utilize it in the most economical manner. Higher steam pressure will be helpful; it should be carefully studied and used wherever the conditions will permit.

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Discussion

R. H. Rice, Turbine Department, General Electric Co., Lynn, Mass.: Higher steam pressures for turbines is one of the obvious, and I believe practical, methods of extending the range of available energy derived from fuel burned under boilers, and thereby extending the range or output from that fuel. In other words, increased output without increase of fuel.

There are several methods by which we can increase the available energy: One is by increasing the steam pressure; another is by increasing the vacuum at the turbine wheels, and another is in extracting more heat from the flue gases in their passage to the atmosphere. I think in considering this question of increased steam pressure we should consider the problem from all these standpoints. I would make this suggestion to the committee, that instead of considering the subject from the standpoint of Rankine-cycle efficiency, it be considered from the standpoint of thermal efficiency. In other words, the percentage of power on the switchboard developed from the available energy in the coal. Power plants of the best type give 18 or 19 per cent. thermal

efficiency. By increasing that, by taking out all the heat from the flues gases which it is possible to take out, brings their temperature down to 125 or 150 deg. F., whereas now they are commonly at 400 or 500 deg. By using all possible means for securing highest vacuum at the turbine wheels. This means a suitable condenser bolted in horizontal or vertical position to the turbine shell, and with the largest opening it is possible to provide between the turbine shell and the condenser. With these we should be able, in plants of very reasonable size, to secure 25 per cent. thermal efficiency, and in the largest plants 28 or 29 per cent. That gain is worth striving for.

Extract More Heat from Flue Gases

Relative to extracting more heat from the gas, this might be done by extending the feed water, or by a regenerative action, by first taking the air for the boiler furnaces through pipes connected with the flues, and extracting the heat from the gases going to the atmosphere.

As to the possibility of using 500 or 600 lb. steam pressure, I do not think that we now have enough knowledge to warrant building a plant for that pressure. But I am satisfied it would be practical at this time to construct a plant of 2000 or 3000 kw. capacity, which would operate safely with 500 or 600 lb. pressure. In the evolution of higher steam pressures we should go the limit, especially if we are building a plant having as small units as above; so that we may try out at one time all the different problems which will arise from such considerable increase in boiler pressure. Results obtained with steam at 300 lb. or 350 lb. pressure are most pleasing. There seems to be no reason why, with materials and with knowledge of designs, we should not go to those pressures directly.

I am of opinion that such pressures would result in a change in the power stations. The steam turbines should be located as near to the boilers as possible, to reduce the high-pressure losses. The construction of those high-pressure mains, pipes and valves involves some problems which are not impossible of solution.

Steel the Limiting Factor

A. L. Meyer, Lukens Steel Co., Coatesville, Penn.: As far as I am able to read this report, it seems that all the manufacturers who make apparatus to give higher steam pressure point to the boiler as the object which they want to make a certainty. So far we have not been able to find any actual tests which I have read in this report, where the boiler pressure has gone to a high temperature of 600 or 700 deg. F. But we feel certain that by the use of the present low-carbon steels, which give a tensile strength of 50,000 to 60,000 lb., the boilermaker will be able to produce a boiler that will stand these pressures. In 1880 Dr. Huston performed some experiments which showed that up to 700 deg. F. the tensile strength was equal to 100 per cent. or better than the original. When the temperature got beyond 700 deg. the curve dropped decidedly. Since that time J. E. Howard, of the Bureau of Standards, Mr. Coleman, from Oberhurst, and the Shelby Co. have performed similar experiments and corroborated Dr. Huston's experiment.

I. E. Moultrop, Edison Electric Illuminating Co., Boston: Someone must work out this problem. There are some limitations in the design and in the material used in the boiler of today. The boiler builders do not care to go beyond 350 lb. today, as far as I understand, owing to the working out of the design and the limitations imposed upon them by commercial steel. Someone should try higher pressures in a small way and go the limit. It is an undertaking none of the utility companies care to take. I think the way to do this is to get the manufacturers to coöperate on the subject—the principal turbine manufacturers, and the auxiliary manufacturers, and boiler manufacturers, should combine, put up a small experimental plant somewhere and actually try higher steam pressures. With the rising prices of coal and labor we must improve the economy of our power stations.

O. F. Junggren, Engineer, Turbine Department, General Electric Co., Schenectady, N. Y.: Engineers are continuously reaching out for improvements, and as long as we use steam as a medium we must ascertain how we can utilize steam to the best advantage. We can only go into the upper range, as the lower range has already been reached and depends upon condensing water. Another way is to superheat steam to a temperature as high as feasible, then run it through the turbine, and finally condense it. But that is not the vital thing. You should increase the pressure and reduce the superheat, as the higher the pressure the greater the improvement, because relatively less steam is transformed to water in the condenser. If we could get rid of the condenser, we would have the ideal condition. We do not know how to do that; but every reduction of one per cent. of quality of steam sent to the condenser is clear gain.

To manufacturers of boilers and of auxiliaries, pressures of 600 and 800 lb. are feasible, and I do not know why that is not the proper way to get at it. The success of the electrical industry has been that the leading men in it have taken steps forward continuously to reach higher efficiency. Of course there will be boiler problems, and the turbine will probably look much different from what it does today operating under pressures of about 200 to 300 lb.

Bureau of Research of the American Society of Heating and Ventilating Engineers

The function of the Bureau of Research is the determination and dissemination of engineering knowledge pertaining to the profession of heating and ventilating and to the equipment and apparatus utilized by the profession at large; it will be run in coöperation with the Bureau of Mines.

The Committee on Research of this society announces the success of its preliminary plans for the establishment of the contemplated Research Bureau and the selection of a director, with the prospect that actual investigations will begin about the middle of the year. The drive for solicitation of funds for the financing of the Bureau which was being prosecuted so vigorously at the time of the annual meeting in January, has been so successful, and the support given not only by other associated organizations, but also by the Government, has been so generous that the success of the undertaking is assured. The committee has been able to secure the services of Prof. John R. Allen as Director of the Bureau. Professor Allen, who was a past-president of the society, is well known for his work in research in heat engineering at both the University of Michigan, where he served many years as professor of mechanical engineering, and of late at the University of Minnesota, where he is dean of engineering and architecture. With Professor Allen's leadership and the cordial interest and support of the United States Bureau of Mines in placing a portion of its magnificent laboratories at Pittsburgh, Penn., at the disposal of the Bureau, it is certain that results will be obtained which will not only prove helpful and constructive in this field of engineering, but also unmistakably demonstrate the ideal relation of the national engineering society to the public in affairs of national economic importance. Professor Allen's offices will be at Pittsburgh.

In the course of a paper read before the Liverpool Engineering Society, says *The Engineer*, B. Rathmell recommended the use of single-, rather than double-acting, compressors in carbon dioxide refrigerating machinery. Such compressors, he said, properly designed, minimize most of the defects commonly found. The compressor can be filled with gas at the full suction pressure; clearance spaces are practically eliminated; large valves with very small lifts can be used; the flow of gas may follow one direction, allowing for the lagging of the cold suction parts and the water-jacketing of the hot discharge parts; higher speeds of revolution can be used than with double-acting compressors; and the piston-rod glands may be kept under the lowest and constant temperature.

Interpretations of the Boiler Code

The following interpretations by the Boiler Code Committee of the American Society of Mechanical Engineers are released for publication:

Case No. 215

Inquiry: **Is it permissible under the requirements of Par. 257 of the Boiler Code to remove the calking edges of plates, butt straps and heads by burning them off by the oxyacetylene process instead of planing, milling or chipping?**

Par. 257. *Calking.* The calking edges of plates, butt straps and heads shall be beveled to an angle not sharper than 70 deg. to the plane of the plate, and as near thereto as practicable. Every portion of the sheared surfaces of the calking edges of plates, butt straps and heads shall be planed, milled or chipped to a depth of not less than $\frac{1}{8}$ in. Calking shall be done with a round-nosed tool.

Reply: **Removing the calking edges of plates, butt straps and heads by the oxyacetylene burning process will not be in compliance with the intent of the Boiler Code in Par. 257.**

Case No. 216

Inquiry: **An interpretation is requested of the relation between Section *a* of Par. 275 of the Boiler Code and Sections *b* and *c*. Section *a* would appear to allow 12 per cent. more relieving capacity to a valve than either Section *b* or *c*.**

Par. 275. Safety-valve capacity may be checked in any one of the three following ways, and if found insufficient, additional capacity shall be provided:

a. By making an accumulation test; that is, by shutting off all other steam-discharge outlets from the boiler and forcing the fires to the maximum. The safety-valve equipment shall be sufficient to prevent an excess pressure beyond that specified in Par. 270. [See under Case 226.]

b. By measuring the maximum amount of fuel that can be burned and computing the corresponding evaporative capacity upon the basis of the heating value of the fuel.

c. By determining the maximum evaporative capacity by measuring the feed water. The sum of the safety-valve capacities marked on the valves shall be equal to or greater than the maximum evaporative capacity of the boiler.

Reply: **The committee purposely limited the requirements for rating of safety valves to 3 per cent. increase in pressure over that at which the valve is set to blow; that is, one-half the maximum allowable increase of 6 per cent., so that a margin of safety represented by the difference between 6 per cent. and 3 per cent. would be provided.**

Case No. 218

Inquiry: **For material to be used as headers and manifolds of superheaters, does that of openhearth extra-heavy lap-welded steel pipe meet the requirements of Par. 11 and the material specifications of the Boiler Code? It is found that the average analyses of such lap-welded pipe appear to meet the physical and chemical requirements of either the boiler-plate steel specifications, or the specifications for steel castings of Class-B Grade, although they do not conform fully to either one separately.**

Par. 9. Cross-pipes connecting the steam and water drums of water-tube boilers, headers, cross-boxes and all pressure parts of the boiler proper over 2-in. pipe size, or equivalent cross-sectional area, shall be of wrought steel, or cast steel of Class-B grade, as designated in the Specifications for Steel Castings, when the maximum allowable working pressure exceeds 160 lb. per sq.in. Malleable iron may be also used when the maximum allowable working pressure does not exceed 200 lb. per sq.in., provided the form and size of the internal cross-section perpendicular to the longest dimension of the box is such that it will fall within a 7 in. by 7 in. rectangle.

Par. 11. Pressure parts of superheaters, separately fired or attached to stationary boilers, unless of the locomotive type, shall be of wrought steel, or cast steel of Class-B grade, as designated in the Specifications for Steel Castings.

Reply: **It is the opinion of the committee that, under the requirements of Pars. 9 and 11, headers and manifolds of superheaters must be constructed from material which, in its initial form of plate or skelp, conforms to one or the other of the specifications given in the Boiler Code for wrought steel; or they may be constructed of cast steel of the Class-B Grade.**

Case No. 219

Inquiry a: **Is it the intention under Par. 184*c* of the Boiler Code to deduct the rivet holes when figuring "the full strength of the plate corresponding to the thickness at the joint?"**

Par. 184c. In the portion of circumferential joints of horizontal return-tubular boilers, exposed to the products of combustion, the shearing strength of the rivets shall be not less than 50 per cent. of the full strength of the plate corresponding to the thickness at the joint.

Reply: **It is not the intention under Par. 184*c* of the Boiler Code to deduct the rivet holes when figuring "the full strength of the plate corresponding to the thickness at the joint."**

Inquiry b: **An interpretation is requested of Par. 201, as regards the constant in the formula for stay-bolts. This paragraph requires that "the spacing of the rivets over the supported surface shall be in conformity with that specified for stay-bolts," but we fail to find a constant which seems to fit the case.**

Par. 201. *Structural Reinforcements.* When channel irons or other members are securely riveted to the boiler heads for attaching through stays, the transverse stress on such members shall not exceed 12,500 lb. per sq.in. In computing the stress the section modulus of the member shall be used without addition for the strength of the plate. The spacing of the rivets over the supported surface shall be in conformity with that specified for stay-bolts.

Reply: **The constant *C* used in the formula for rivets shall be that given in Par. 199 for stays screwed through the plates with the ends riveted over. This means that *C* shall be 112 or 120, depending on the thickness of the plate.**

Par. 199. C = 112 for stays screwed through plates not over $\frac{7}{16}$-in. thick with ends riveted over.
C = 120 for stays screwed through plates over $\frac{7}{16}$-in. thick with ends riveted over.

Case No. 221

Inquiry: **Is it necessary under the requirements of the Boiler Code that small vertical tubular boilers such as are used for clothes-pressing, vulcanizing and laundry service, shall be fitted with gage-cocks when a water-gage glass is attached?**

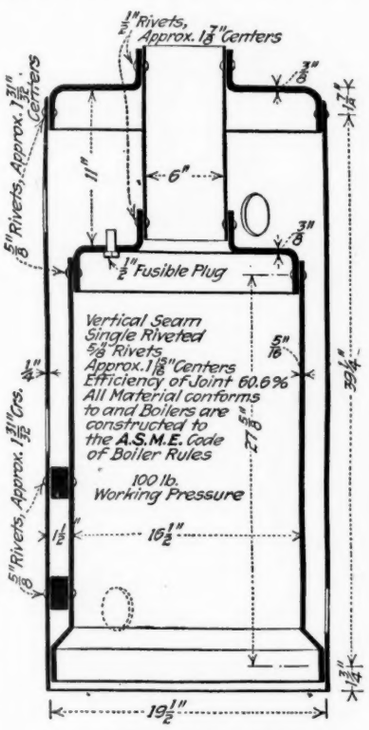
Reply: **It is the opinion of the committee that a boiler of this type that is operated with a fixed water level should be fitted with both water gage-glass and gage-cocks; or two gage-glasses, as indicated in Par. 294.**

Par. 294. Each boiler shall have three or more gage-cocks, located within the range of the visible length of the water glass, except when such boiler has two water glasses with independent connections to the boiler and located on the same horizontal line and not less than 2 ft. apart.

Case No. 222

Inquiry: **What is the application of the limitation of length of stay-bolts given in Par. 200 of the Boiler Code, that must be drilled with telltale holes in their outside ends? Does this length of stay-bolt apply to inside distance between plates stayed or to the outside length of the bolt over all?**

Par. 200. *Stay-Bolts.* The ends of screwed stay-bolts shall be riveted over or upset by equivalent process. The outside ends of solid stay-bolts, 8 in. and less in length, shall be drilled with a hole at least $\frac{1}{4}$ in. diameter to a depth extending at least $\frac{1}{2}$ in. beyond the inside of the plates or hollow stay-bolts may be used. On boilers having a grate area not exceeding 15 sq.ft., or the equivalent in gas- or oil-fired boilers, the drilling of stay-bolts is optional. Solid stay-bolts over 8 in. long, and flexible stay-bolts of either the jointed or ball-and-socket type, need not be drilled. Stay-bolts used in water-legs of water tube boilers shall be hollow and drilled at both ends, irrespective of their length.



SINGLE-FLUE BOILER

Reply: **Par. 200 of the Code specifies that "stay-bolts used in water-legs of water-tube boilers shall be hollow or drilled at both ends irrespective of their length." Par. 220*d* specifies that "the length of a stay between supports shall be measured from the inner faces of the stayed plates."**

CASE No. 223

Inquiry: Is it necessary under the requirements of the Boiler Code to provide staying in a single-flue boiler 19½ in. in diameter by 43 in. high having a 16½-in. furnace, crown sheet of which is connected to the top head of the boiler by a 6-in. flue?

Reply: Inasmuch as the diameter of the furnace is less than 18 in., it is evident that under the requirements of Par. 239 the furnace will not require staying. There remains therefore only the crown sheet, top head of the boiler and the flue to be considered. Par. 203*d* or the latter part of Par. 216 are applicable to the crown sheet or the top head if formed of flat sheets. If, on the other hand, the crown sheet and top head are dished the maximum allowable working pressure is calculated from Par. 195. Par. 241 applies to the flue.

[In order that the reply may be intelligible the inquiry should have stated that the thickness of the furnace is $\frac{5}{16}$, its height 27⅝ and the pressure 100 lb. A reproduction of the blueprint accompanying the inquiry is reproduced herewith.—Editor.]

Par. 239 specifies that unstayed furnaces more than 12 in. in diameter when riveted, of seamless construction or when lap welded by the forging process shall have walls not less than $\frac{5}{16}$ in. thick. The maximum allowable working pressure for such furnaces, from 12 to 18 in. diameter inclusive, of a length not more than 4½ diameters and not more than 120 times the thickness of the plate is determined as follows:

$$P = \frac{51.5}{D}\left[(18.75 \times T) - (1.03 \times L)\right]$$

where

P = Maximum allowable working pressure in lb. per sq.in.;
D = Outside diameter of furnace in inches;
L = Total length of furnace between centers of head rivet seams (not length of a section) in inches;
T = Thickness of furnace walls in sixteenths of an inch.

This gives an allowable pressure for the unstayed furnace in excess of the required 100 lb.

CASE No. 224

Inquiry: Is it necessary that firebox steel of lower tensile strength than specified in Par. 28*a*, the use of which is sanctioned in Par. 28*c*, shall have a minimum carbon limit of 0.12 per cent. as specified for firebox steel in Par. 25?

Par. 25. *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

	FLANGE	FIREBOX
Carbon		Plates ¾ in. thick and under, 0.12—0.25 per cent Plates over ¾ in. thick....0.12—0.30 per cent
Manganese	0.30—0.60 per cent	0.30—0.50 per cent
Phosphorus, Acid	Not over 0.05 per cent	Not over 0.04 per cent
Phosphorus, Basic	Not over 0.04 per cent	Not over 0.035 per cent
Sulphur	Not over 0.05 per cent	Not over 0.04 per cent

Par. 28a. *Tension Tests.* The material shall conform to the following requirements as to tensile properties:

	FLANGE	FIREBOX
Tensile strength, lb. per sq. in.	55,000—65,000	55,000—65,000
Yield point, min., lb. per sq. in.	0.5 tens. str. 1,500,000	0.5 tens. str. 1,500,000
Elongation in 8-in., min., per cent (See Par. 29)	Tens. str.	Tens. str.

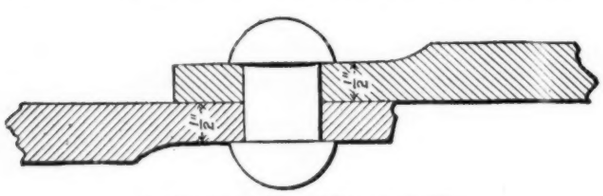
Par. 28c. If desired, steel of lower tensile strength than the above may be used in an entire boiler, or part thereof, the desired tensile limits to be specified, having a range of 10,000 lb. per sq.in. for both flange and firebox, the steel to conform in all respects to the other corresponding requirements herein specified, and to be stamped with the minimum tensile strength of the stipulated range.

Reply: The minimum carbon limit of 0.12 per cent. given in Par. 25 applies to firebox steel having a tensile strength of 55,000 to 65,000 lb. per sq.in. and does not apply to steel of a lower tensile strength, the use of which is sanctioned in Par. 28*c*.

CASE No. 225

Inquiry: Is it necessary under the requirement of Par. 185 of the Boiler Code to plane down to ½ in. the thickness of the shell plate and heads at the head seams, or does this requirement apply to girth seams in shell plates only?

Par. 185. When shell plates exceed $\frac{7}{16}$ in. in thickness in horizontal return-tubular boilers, the portion of the plates



PLATES WITH EDGES PLANED

forming the laps of the circumferential joints, where exposed to the fire or products of combustion, shall be planed or milled down as shown in the figure, to ½ in. thickness, provided the requirements in Par. 184 are complied with.

The requirements of Par. 184 are that the strength of the circumferential seam shall be at least 50 per cent. of that of the longitudinal seam in the case of heads not stayed by tubes, or 35 per cent. if one-half or more of the load which would be caused by the pressure acting on an unstayed solid head is relieved by the effect of tubes or through stays; also that in the portion of the circumferential joint exposed to the fire or to the products of combustion the shearing strength of the rivets shall not be less than 50 per cent. of the full strength of the plate.

Reply: It is the intent of the Code that Par. 185 shall apply to the plates at all circumferential joints on the shell of a horizontal return-tubular boiler where exposed to the fire or products of combustion. It therefore applies to a joint between the shell and the head where the joint in the shell is exposed to the products of combustion, in which case the plate is reduced in thickness if over $\frac{9}{16}$ in. in thickness, but the flange of the head is not so reduced.

CASE No. 226

Inquiry: Is not the basis of determination of the relieving capacity of pop safety valves given in Par. 274 of the new edition of the Boiler Code a misprint? The bases of 6 lb., 5 lb. and 3 lb. of steam per hour per sq.ft. of boiler-heating surface for the different types of boilers do not seem to be in line with the other data given in the Boiler Code and not in line with good practice.

Par. 274. The total relieving capacity of the safety valve or valves required on a boiler shall be not less than that determined on the basis of 6 lb. of steam per hour per sq.ft. of boiler-heating surface for water-tube boilers. For all other types of power boilers the total relieving capacity shall be not less than that determined on the basis of 5 lb. of steam per hour per sq.ft. of boiler-heating surface for boilers with maximum allowable working pressures above 100 lb., and on the basis of 3 lb. of steam per hour per sq.ft. of boiler-heating surface for boilers with maximum allowable working pressures at or below 100 lb. per sq.in.

Reply: The decision to base the required minimum capacity of safety valves on heating surface was made by the committee as a result of investigation of general average of operating duty for boilers in practice, it having been found that water-tube boilers rarely exceed a condition of forcing which will evaporate more than 6 lb. of steam per hour per sq.ft. of boiler-heating surface, whereas 5 lb. per hour seems to be the limit for high-pressure boilers of any other type; similarly practice with boilers operated at pressures of 100 lb. and under indicated that 3 lb. of steam per hour was a reasonably high figure. These relieving rates were therefore adopted; the provision of Par. 270 limiting the rise of pressure to 6 per cent. above the maximum allowable working pressure being ample for protection against any boiler emergency, as in case the evaporation is over the figure specified, additional safety-valve capacity must be added to meet this requirement.

Par. 270. The safety-valve capacity for each boiler shall be such that the safety valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6 per cent. above the maximum allowable working pressure, or more than 6 per cent. above the highest pressure to which any valve is set.

CASE No. 227

Inquiry a: Is Par. 12 of the Boiler Code intended to prohibit the use of cast iron on boiler nozzles, flanges and supporting lugs for any temperature or pressure? And does the rule permit the use of cast iron on superheater mountings for temperatures of less than 450 deg.?

Par. 12. Cast iron shall not be used for nozzles or flanges attached directly to the boiler for any pressure or temperature, nor for boiler and super-heater mountings such as connecting pipes, fittings, valves and their bonnets, for steam temperatures of over 450 deg. F.

Reply: Par. 12 is not intended to prohibit the use of cast iron for supporting lugs or for boiler nozzles or flanges, provided such nozzles or flanges are not attached directly to the boiler or used for temperatures in excess of 450 deg. F.

Inquiry b: How far from the boiler are the Rules of the Boiler Code intended to apply? That is, do they cover beyond the second stop valve and do they extend indefinitely along the header and steam pipe?

Reply: The rules are intended to apply to the boiler structure only as far as and including the nozzles or flanges attached directly to the boiler and to the various accessories and appliances as specified. In Par. 305 of the Code, provisions are made to allow for expansion and contraction of steam mains and for the use of steam reservoirs on the steam mains in case there are pulsations of the steam currents that might cause vibration of the boiler shell plates. This paragraph is included for the protection of the boiler and is not intended to have a bearing on the general subject of design of steam mains.

Par. 305. *Steam Mains.* Provisions shall be made for the expansion and contraction of steam mains connected to boilers, by providing substantial anchorage at suitable points, so that there shall be no undue strain transmitted to the boiler. Steam reservoirs shall be used on steam mains when heavy pulsations of the steam currents cause vibration of the boiler shell plates.

Engineering Council Notes

Contributed by M. O. LEIGHTON, Chairman
National Service Committee

Engineers who were enrolled in the Reserve Corps at the beginning of the war will be interested in the circumstances related below. How many engineers had a similar experience? All who did are urged to send a detailed statement to the National Service Committee.

The following letter was addressed to the American Society of Civil Engineers by one of its associate-members resident in the Philippines, and finally came to the Washington office of Engineering Council:

The American Society of Civil Engineers,
Dear Sirs:

As you are doubtless aware, the American Society of Civil Engineers during the war played a very considerable part in obtaining the services of engineers for the Army. Literature descriptive of the Engineer Officers' Reserve Corps was circulated throughout our membership and the society's appeal for men was probably responsible for a very large number of volunteers. In view of this fact, I am taking the liberty of advising you of certain instances in which the War Department through the Chief of Engineers seems to have violated the agreement under which the engineer officers were induced to offer their services.

Among other things, we were informed that reserve corps officers when ordered to active duty would receive the pay and allowance that officers ordinarily do when changing stations. Any number of western engineers, several of them located in Alaska, applied for commissions in the first engineer reserve corps. After their applications had gone forward the reserve corps was abolished by the War Department. Without receiving any information to this effect these men were telegraphed offers of commissions in the Engineers, U. S. A. They were accepted and ordered to Camp A. A. Humphreys, Va., for duty as students. Upon their arrival there they were informed that they would receive no travel allowances at all. The seven cents a mile that they expected was not due them because they had accepted commissions in the regular army, not in the reserve corps. This was the first intimation that they had as to their new status. Most of the men, particularly those from Alaska, had been to a very considerable expense in traveling, as much as $350 in some cases.

Another instance, one which covers my own case, occurred as follows: Some twenty-five or thirty of us entered the service in the Philippine Islands. We were discharged in the States, most of us in the eastern part. Our discharges came just too late to catch the December transport for the Philippines, so we were forced to wait for the January boat which arrives in Manila about February 15. We were thus over two months without pay, our army pay having stopped on the date of our discharge and our pay as civilians not beginning until our arrival in the Philippines. Anticipating these conditions, some of the men requested that they be ordered to the Philippines and discharged there or that they be returned to the inactive list in the reserve corps so that they could return to their homes with pay. Both of these requests were refused and the men discharged along with the rest.

On May 1 a letter was addressed to the Secretary of War in which the above communication was quoted with a request as follows:

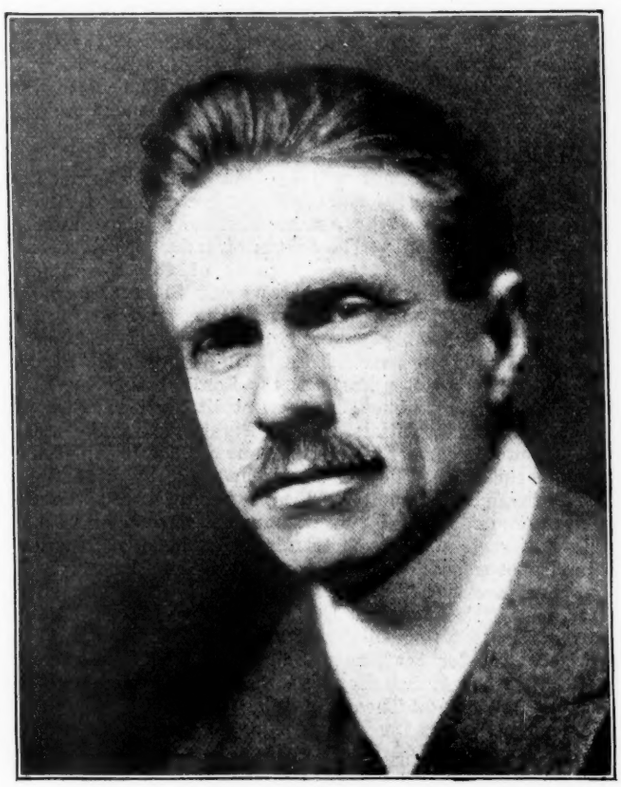
> Will you be good enough to inform Engineering Council through the undersigned whether the facts as related in the letter above quoted are interpreted by the War Department in the same way as by Mr. ——— and whether there is an official intention to present the facts to Congress for the purpose of securing authority to reimburse discharged engineer officers of the Army whose experiences were similar to the above.

Up to May 24 no response had been received from the War Department, but we have hopes. While the author of the above letter recites an unfortunate train of circumstances, which seemingly reflects discredit on someone, judgment should be tempered with consideration.

Charles Edwin Knox

Charles E. Knox, one of New York's leading consulting electrical engineers, died at the age of 47 years, Sunday evening at St. Luke's Hospital, New York City, after a short illness of blood poisoning. Mr. Knox was born Sept. 17, 1871, at Atlanta, Ga. He came to New York City at an early age, attended New York City College, and the School of Mines at Columbia University, graduating as an electrical engineer in 1892. After graduating he was employed, in research work, in the laboratories of Queen & Co., Philadelphia, Penn. In 1893 Mr. Knox took the "Expert's Course" of the General Electric Co., at Lynn, Mass., and at the end of the year entered the employ of C. O. Mailloux as engineering assistant in the general practice of consulting engineering. From 1907 to 1913 he practiced as consulting engineer under the firm name of C. O. Mailloux & C. E. Knox, and since May, 1913, has practiced consulting engineering under his own name at 101 Park Ave., New York City.

Mr. Knox has always been greatly interested in laboratory, mechanical and electrical work and when the School of Mines at Columbia University opened their course of electrical engineering in 1889 he made application and was admitted in 1890.



CHARLES EDWIN KNOX

The particular branch of engineering practice to which his office is devoted is the designing of electric-light and power equipments for industrial plants, office buildings, hotels, factories and hospitals, department stores, etc., and elevator installations of all kinds. Some of the more important building installations, in New York City, on which he has acted as consulting engineer on the elevator and electrical equipment include the Wolworth, Municipal, Equitable, Metropolitan Life, Pennsylvania and Commodore Hotels, Columbia University Buildings,and Metropolitan Museum of Fine Arts.

In all Mr. Knox has been consulting electrical engineer on several hundred buildings in various parts of this country. He was considered an elevator expert of the highest standing, the height of the Equitable Building being determined by his report made to the owners on the estimated

elevator traffic of that building. Among his many war activities he was consulting engineer on the elevator installation in the U. S. Army Base Buildings in Brooklyn and Boston, the Brooklyn building having an installation of 90 elevators.

Mr. Knox was a member of many societies and clubs among which are: Fellow in the American Institute of Electrical Engineers, member of the New York Electrical Society, Institute of Consulting Engineers, Engineers' Club of New York, Columbia University Club and Columbia University School of Mines Alumni Association.

A. S. M. E. Spring Meeting

The American Society of Mechanical Engineers will hold its spring meeting in Detroit, Mich., June 6-19, with headquarters at the Hotel Statler. Monday forenoon will be occupied by registration of members and visitors, council and business meetings, etc. In the evening Mayor James Couzens will make an address of welcome. On Tuesday forenoon following the professional session will be the research session under the auspices of the Research Committee. The papers to be presented at this session are as follows: "The Present Condition of Research in the United States," by Arthur M. Greene, Jr.; "Research Work on Malleable Iron," by Enrique Touceda; "Reports of Sub-Committees on Flow Meters, Bearing Metals and Lubrication"; "The Organization and Conduct of an Industrial Laboratory," by A. D. Little and H. E. Howe. The Industrial Relations sessions will be held in the afternoon, at which the following papers will be presented: "Industrial Personnel Relations," by Arthur M. Young (contributed by the Chicago Section); "The Status of Industrial Relations," by L. P. Alford; "Certain Aspects of the Management Problem," by Magnus W. Alexander. Simultaneous sessions will be held on Wednesday. At the Mid-West Sections session the following papers will be presented: "Central Station Heating in Detroit," by J. H. Walker, and "Production of Liberty Motor Parts at the Ford Plants," by W. F. Verner—both contributed by the Detroit Section; "Fire Engines and the Essentials of Fire Fighting," by C. H. Fox (contributed by the Cincinnati Section); Electrical Method for Measuring the Flow of Fluids in Pipes, by J. M. Spitzglass (contributed by the Chicago Section). At the Gas Power session J. W. Morton will present a paper on "Crude-Oil Motor versus Steam Engines in Marine Practice." Simultaneous sessions will also be held on Thursday. At the Fuel session: "Pulverized Coal as a Fuel," by N. C. Harrison; "Economy of Certain Arizona Steam-Electric Power Plants Using Oil Fuel," by C. R. Weymouth; "Pulverized Coal for Stationary Boilers," by H. G. Barnhurst and Frederick A. Scheffler. At the General session: "Elements of a General Theory of Wing Design," by Walter C. Durfee; "Air Fans for Driving Electric Generators on Airplanes," by Capt. G. Francis Gray, Lieut. John W. Reed and P. N. Elderkin; "Mechanical Lifts, Past and Present and a New Method for Their Balancing," by Lieut. J. F. Robbins; "General Equations for the Design of Riveted Butt Joints," by A. A. Adler; "The Economical Section of a Water Conduit," by Cary T. Hutchinson. Arrangements have been made for trips to many of the big local plants.

Chicago Section A. S. M. E. Close Season

On May 29 at the Hotel LaSalle the Chicago Section of the American Society of Mechanical Engineers held its last meeting of the season. It was ladies' night and there was music by the orchestra and community singing. Chairman Lord read in part the report of the Aims and Organization Committee and outlined briefly some of the radical resolutions that are to be presented at the spring meeting in Detroit. These resolutions recognize the progressive thought of the day relative to the engineer and his relation to his work, the need of guiding legislation relating to engineering, and the necessity of closer coöperation between engineering bodies all along the line. One of the big things suggested was the formation of an independent organization having the power to speak for the engineering profession, this to be made up of local state and national groups of the various societies. Industrial engineering was considered technical and on a par with other engineering work.

The speaker of the evening was Dr. William S. Sadler, who gave a very interesting address on "Stress and Strain," dealing with physical engineering from the health standpoint.

For the coming season the nominating committee selected the following section officers, who were unanimously elected: A. L. Rice, chairman; J. L. Hecht, vice-chairman; G. R. Brandon, secretary; J. M. Stannard and F. A. Lindberg, other members of the executive committee.

Worcester Engineers Meet

The Worcester Section of the American Society of Mechanical Engineers held its May meeting and dinner at the Hotel Bancroft on Wednesday evening, May 28. The speakers were Major John F. Tinsley, chairman of the Worcester Fuel Conservation Committee, whose subject was Fuel Serving in Industrial Plants as Affected by War-time Necessity, and Dr. Ira F. Hollis, who talked upon Recognition for Distinguished Work in Mechanical Engineering and Encouragement toward Better Service.

Major Tinsley said that in 1917 plants his committee had recommended an average of five changes per plant, or revisions in plant or practice, 85 per cent. of which had been complied with before subsequent inspection. No recommendations were made which required new apparatus or an extensive overhauling. The principal sources of unnecessary loss were belts too tight or too loose, motors running underloaded, shafting out of line, uncovered high-pressure steam pipes, machines running idle, open doors and windows, dirty windows making more artificial light necessary. Large savings were made by revising boiler room practice and indicating engines. Much educational literature was circulated.

In the late summer or early fall of 1917, 17 plants used 31,232 tons of coal per month. In the corresponding months of 1918 the same plants used 27,104 tons with practically the same number of operatives at work. The average saving was 11.9 per cent. for the large plants, as against 21.6 for the small. Thirteen plants purchasing power used in 1917 474,841 kw.-hr. and in the same months of 1918 387,806 kw.-hr., a saving of 18.3 per cent. The six larger showed an average saving of 17.8 per cent., the seven smaller 29 per cent.

Dr. Hollis presented the results of an exhaustive study as to what the scientific and engineering societies of this and other countries are doing in the way of recognition of meritorious service; something that shall be the equivalent of the distinguished service medal, something to let one know that he stands well with the kind of men who know the kind of work that he is doing America is behind the older countries in this respect, and the American Society of Mechanical Engineers has done little beyond conferring honorary memberships and awarding prizes for papers from juniors.

Annual Convention of the N. G. E. A.

On June 2 and 3 the National Gas Engine Association held its twelfth annual meeting at the Hotel Sherman, Chicago. The convention was divided into several group sessions dealing with the commercial end of the business, the stationary and oil engine, the farm engine, the tractor, the farm lighting plant and accessories. In these various sections numerous interesting papers dealing mostly with trade and sales problems were presented. At a Victory dinner Tuesday evening the topics of discussion were "American Branch Banks Abroad" and the "Relations of Capital and Labor Before and After the War." Officers, elected for the ensuing year were: L. M. Ward, president; T. C. Menger, first vice president; Henry Kennedy, second vice president; O. M. Knoblock, treasurer; H. R. Brate, secretary; Richard De Forest, 1 year; F. E. McKee, 2 years, George Cormack, 3 years, executive committee.

Personals

Charles A. Greene, Chicago representative for The Borden Co., of Warren, Ohio, has opened an office at Room 501, 549 West Washington Boulevard, Chicago.

William L. De Baufre has resigned his position with the Naval Engineering Experimental Station, Annapolis, Md., to become designing engineer of the Precision Instrument Co., Detroit, Mich.

John R. Allen, dean of the college of engineering and architecture, University of Minnesota, has been appointed director of the Research Bureau of the American Society of Heating and Ventilating Engineers. He will take charge of the work on Aug. 1.

S. C. Orrell, recently manager of the Minneapolis office of the Allis-Chalmers Manufacturing Co., of Milwaukee, has resigned to assume charge of the Chicago office of the Murray Iron Works Co. of Burlington, Iowa.

Frederick L. Ray, who has had charge of the power plants of the Merchants' Heat & Light Co., Indianapolis, and previous to that was for nine years superintendent of steam equipment with the Louisville Railway Co., has accepted a position as superintendent of power plants of the Union Traction Co. of Indiana.

John D. Cameron, who formerly carried on a jobbing and steam supply business at Providence, R. I., has been succeeded by Cameron & Ingalls Engineering Co. at 125 Canal St., same city. Chauncey H. Ingalls, who is the additional member of the firm, has, for a number of years, been associated with the United States Finishing Co. as mechanical superintendent of its various plants, will have charge of the engineering department of the new company.

Engineering Affairs

The Canadian Association of Stationary Engineers will hold its next annual convention at Brantford, Ont., June 24-26.

The American Boiler Manufacturers' Association will hold its thirty-first annual convention at the Lafayette Hotel, Buffalo, N. Y., June 23-24. An interesting program is being arranged.

The Material Handling Machinery Manufacturers' Association will hold a coalition meeting at the Hotel Astor, New York City, on June 11, which should interest all manufacturers of mechanical handling equipment. Many speakers of note will address the meeting, and at the general "forum" discussion which will be conducted in the afternoon there will be taken up the subjects of ways and means for promoting a more general knowledge of the great economies which may be effected through the use of mechanical handling equipment, etc. A mass gathering of various clubs and city officials is planned for the evening session.

The Institution of Operating Engineers of Philadelphia held its May meeting on the 19th at the Philadelphia Yacht Club at Essington, on the Delaware River. The institution is composed of most of the chief engineers of Philadelphia; was instituted September 22, 1899, and incorporated under the laws of Pennsylvania October 13, 1899. It is now in a flourishing condition. Through the efforts of the committee the institution was tendered an invitation to visit the plant of the Hog Island Shipyard. Every member was delighted and surprised at the gigantic work that has been accomplished in so short a time at this plant. After looking through the yard, they were escorted on the ship "Sangus" which was about ready for sea. The engine and boiler room was, of course, the most interesting part of the ship to the members. After leaving the shipyard the party proceeded to the Philadelphia Yacht Club, where a bountiful repast was served. Mr. McLaughlin, the Director of Supplies of Philadelphia, made the speech of the evening. This was followed by speeches by the past presidents present, and others. There were eighty-three present, and all voted the meeting a very pleasant affair. The president this year is Robert Cheney, chief engineer of the Stock Exchange Building. The Secretary and Treasurer is Wm. D. Mahn, of Walsh Packing Co.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.75@3.25
Philadelphia, gross tons	4.27@4.90	5.95@5.50
New York, gross tons	4.62@5.29	5.29@5.85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.55

Pocahontas and New River are quoted at $4.70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7.90	Pea	4.90	6.65
Egg	5.95	7.80	Buckwheat	3.40	5.15
Stove	6.20	8.05	Rice	2.75	4.50
Chestnut	6.30	8.15	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.75 @ 2.95	2.95 @ 3.25
Clearfield County	2.50 @ 2.75	2.80 @ 2.95
Reynoldsville	2.50 @ 2.75	2.75 @ 2.95
Quemahoning	2.65 @ 2.85	2.95 @ 3.10
Somerset County (best grades)	2.50 @ 2.75	2.95 @ 3.10
Somerset County (poorer grades)	2.00 @ 2.35	2.50 @ 2.75
Western Maryland	2.25 @ 2.50	2.50 @ 2.75
Fairmont	2.00 @ 2.25	2.35 @ 2.50
Latrobe	2.10 @ 2.25	2.25 @ 2.40
Greensburg	2.25 @ 2.35	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.60 @ 2.75
Westmoreland run-of-mine	2.35 @ 2.60	2.35 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	6.05	7.90	Rice	2.75	3.65
Stove	6.30	8.15	Boiler	2.50	3.50
Nut	6.40	8.25	Barley	2.25	3.15
Pea	5.00	6.60	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.95@$4.60
Corona	3.50
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....	.....
Williamson County			
Prepared sizes, lump, egg, nut	$2.55	$2.55	$2.00@2.25
Mine-run	2.35	2.20	1.60@1.75
Screenings	2.20	2.05	1.15@1.30
3-in. lump	....	2.30	.....
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St Louis is $1.07; boter rates 92½c.

New Construction

PROPOSED WORK

N. H., Nashua—The Nashua Manufacturing Co. will install a steam heating plant in the 7 story, 122 x 560 ft. factory which it plans to build. Total estimated cost, $750,000. Lockwood-Greene & Co., 101 Park Ave., New York City, Engr.

Mass., Springfield—The National Equipment Co., 662 North Main St., has awarded the contract for the construction of a 3 story, 100 x 372 ft. factory, to A. E. Stephens Co., 128 Chestnut St. A steam heating system and electric power will be installed in same. Total estimated cost, $100,000.

Conn., Bridgeport—The Columbia Graphophone Co., Barnum Ave., will install a steam heating plant and electric power in the 6 story, 80 x 240 ft. factory which it plans to build. Total estimated cost, $200,000.

Conn., Greenwich—R. A. Cowles, c/o F. F. French Co., Arch., 299 Madison Ave., New York City, will install a steam heating plant in the 12 or 15 story hotel which it plans to build on Boston Rd. and Greenwich Ave. Total estimated cost, $1,000,000.

N. Y., Brooklyn—The Avondale Building Co., c/o Shampan & Shampan, Arch., 50 Court St., will install a steam heating plant in the theatre which it plans to build on Coney Island Ave. and East 12th St. Total estimated cost, $250,000.

N. Y., Brooklyn—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until June 11 for building an extension to the heating plant and distribution system at the Naval Hospital here. Estimated cost, $830,000. Specification No. 3891.

N. Y., Brooklyn—B. A. Cushman Sons, Inc., 49 Manhattan St., New York City, will install a steam heating plant in the 3 story, 140 x 200 ft. bakery which they plan to build on Atlantic and Troy Ave. Total estimated cost, $100,000. L. S. Beardsley, 40 West 32nd St., New York City, Engr.

N. Y., Brooklyn—Parshelsky Bros., Johnson Ave., will install a steam heating plant in the 1 story, 200 x 200 ft. factory which it plans to build on Morgan and Montrose Ave. Total estimated cost, $150,000. L. Allmendinger, 20 Palmetto St., Arch.

N. Y., Cohoes—The Board of Education received bids for installing heating plant in the high school, from C. Dwyer, 18 Chuctanunda St., Amsterdam, $29,253. Tooker & Marsh, 101 Park Ave., New York City, Engr. Noted Jan. 14.

N. Y., New York—J. Eichler Brewing Co., 3582 3rd Ave., has had plans prepared by A. G. Koenig, Engr., 405 Lexington Ave., for altering its 3 story, 62 x 84 ft. ice plant on 169th St. near 3rd Ave. Estimated cost, $37,000.

N. Y., New York—D. L. Elliman & Co., 15-17 East 49th St., will install a steam heating plant in the 10 story, 34 x 100 ft. office building which it plans to build on 49th St., between 5th and Madison Ave. Total estimated cost, $150,000. Cross & Cross, 681 5th Ave., Engr.

N. Y., New York—The W. Fox Film Corp., 126 West 46th St., will install a steam heating plant in the 3 story, 100 x 190 ft. studio which it plans to build on 10th Ave., between 55th and 56th St. Total estimated cost, $1,000,000. Owner will build by day labor under the supervision of A. Allen, 128 Broadway, New York City, Representative.

N. Y., New York—The League of Political Education, 15 West 44th St., will install a steam heating plant in the 5 story, 100 x 125 ft. institute which it plans to build on 43rd St. and Broadway. Total estimated cost, $150,000. McKimm, Mead & White, 101 Park Ave., Arch.

N. Y., New York—F. W. Schweirs & Sons, 52 Vanderbilt Ave., will install a steam heating plant in the 3 story, 100 x 100 ft. warehouse which it plans to build on 11th Ave. and 48th St. Total estimated cost, $100,000. R. T. Lyons, Inc., 52 Vanderbilt Ave., Arch.

N. Y., New York—The Springfield Tire Co., 200 West 57th St., will install a steam heating plant in the 4 story, 100 x 115 ft. warehouse and 1 story, 60 x 100 ft. service station which it plans to build on 10th Ave. and 54th St. Total estimated cost, $100,000. E. Necarsulmer, 507 5th Ave., Arch.

N. Y., Salamanca—The Board of Education is receiving bids for installing a new heating and ventilating system in the Maple St. school. Estimated cost, $16,000.

N. J., Jersey City—The Board of Commissioners plans to install a steam heating plant, in connection with building an addition to the hospital on Baldwin Ave. and Montgomery St. Total estimated cost, $900,000. F. Sutton, 80 Broadway, New York City, Engr.

Penn., Shenandoah—The city is having plans prepared by Gannett, Seelye & Fleming, Engrs., 204 Locust St., Harrisburg, for improving the waterworks system, to include pumping station pumps, motor, etc. D. T. Glover, City Engr.

La., New Orleans—The American Sugar Refining Co., 132 North Peters St., plans to remodel its power plant and install new dynamos and machinery.

Ohio, Cleveland—W. Vretman, 413 Engineers Bldg., will install a steam heating plant in the 2 story, 95 x 120 ft. commercial building and theatre which it plans to build on West 117th St. and Lorain Ave. Total estimated cost, $125,000. Whitworth & Johnson, 413 Engineers Bldg., Arch.

Ohio, Kent—The Kent Hotel Co. has awarded the contract for the construction of a 3 story hotel, to the Crowell-Lundoff Little Co., 5716 Euclid Ave., Cleveland. A steam heating plant will be installed in same. Total estimated cost, $150,000.

Ind., Perrysville—The Perrysville Stove Works is in the market for a motor for machine shop, blower for cupelo and traveling crane, etc.

Mich., Marquette—The City Commissioners will receive bids until June 16 for the construction of a light and power plant. T. W. Orbison, Appleton, Engr.

Mich., Royal Oak—The Board of Education, Peter Smith Bldg., Detroit, will install a steam boiler, pump and accessories in the school which it plans to build on Berkley Ave. C. A. Dunton, Pres. Van Leyen, Schilling & Keough, 1115 Union Trust Bldg., Detroit, Arch.

Ill., Chicago—The Independence State Bank, 1215 South Kedzie St., has awarded the contract for the construction of a 3 story, 66 x 118 ft. bank on 12th St. and Kedzie Ave., to R. Sollit & Sons Construction Co., 5 South Wabash Ave. A steam heating plant will be installed in same. Total estimated cost, $125,000.

Ill., Chicago—J. L. Kraft Bros. Cheese Co., 359 River St., will install a steam heating plant in the 6-story, 120 x 275 ft. factory which it plans to build on Oak and Crosby St. Total estimated cost, $500,000. Architect not selected.

Ill., Chicago.—The National Tea Co., 2715 West North Ave., will install a steam heating plant in the 6-story, 120 x 125 ft. warehouse which it plans to build on Oak and Crosby St. Total estimated cost, $275,000. J. B. Bohm & Son, 138 North La Salle St., Arch.

Wis., Sheboygan—The Wadham Oil Co., 359 Clinton St., is in the market for several pumps and 5 centrifugal gas tanks to be installed in the 2-story, 60 x 150 ft. warehouse which it plans to build on Michigan Ave. Leiser & Holst, 105 Wells St., Milwaukee, Arch.

Wis., Sheboygan—C. A. Honold, 821 Pennsylvania Ave., will receive bids until June 15 for the construction of a 40 x 90 ft. storage battery and electrical station. Estimated cost, $20,000. Engineer not selected.

Minn., Albert Lea—C. J. Dudley, City Clk., will soon award the contract for building a 1,500,000 gal. reservoir, 125,000 gal. tank and tower, both 800 gal. per minute, centrifugal pump direct conected to a 15 h.p. steam turbine, piping, valves and water mains, etc. Estimated cost, $50,000. J. H. A. Brahtz, 506 Chamber of Commerce Bldg., St. Paul, Engr. Former bids rejected.

Minn., Hibbing—The Oliver Mining Co., Wolvin Bldg., Duluth, will install a steam heating plant with mechanical ventilating system in the 3 story, 45 x 150 ft. hospital which it plans to build on 4th Ave. and Mesaba St. Total estimated cost. $250,000.

Kan., Hays—The state, c/o J. A. Kimball, State House, Topeka, will receive bids until June 10 for one 250 hp. auto horizontal side crank engine, 275 r.p.m., 100 lb. pressure, 4 valve or uniform type, with one 150 k.v.a., 200 v, 60 cycle, 3 phase d.c. generator; two 25 k.w. and two 15 kw., 220 to 110 volts transformers; also an auto lubricating system. R. J. Gamble, Topeka, Arch.

Kan., Kansas City—The city will receive bids until June 18 for one 10,000 or one 6,000 k.w. turbo generating unit; two 600 hp. water tube boilers and auto stokers; 1 turbine driven boiler feed pump; and 1 brick and concrete transformer house; 1 sub-station complete poles, coffers and material for new lines. A. H. Strickland, Purch. Agt. W. Barclay, City Engr.

Kan., Oswego—The city voted $50,000 bonds for the construction of a light and power plant. Plans include the installation of oil burning engines of sufficient capacity to take care of the growth of the town for many years. Noted March 25.

N. D., Leeds—The city plans to build a 500,000 gal. steel tank on a 100 ft. steel tower, a 100,000 gal. reservoir and settling basin; brick pump house and also the installation of a 100 gal. per minute pump with engine, etc. Estimated cost, $35,000.

Mo., St. Louis—The Argonne Realty Co., 2407 North Broadway, will install a steam heating plant in the 5 story, 62 x 219 ft. hotel which it plans to build at 3664 Washington St. Total estimated cost, $250,000.

Mo., St. Louis—The Maxwelton Amusement Co., c/o the Lindell Theatre, Grand and Herbert St., plan to convert the mercantile building into a theatre and install air cooling and ventilating system in same. Total estimated cost, $110,000. W. Goldman, Pres.

Mo., St. Louis—R. M. Mulligan, Commissioner of School Buildings, 9th and Locust St., is receiving bids for furnishing and installing 5 electric generator units in St. Louis high schools; 3 units to be 3-phase, alternating current motor drive, 125 hp. at 40 rating; 2 units to be 3 phase, alternating current motor drive, 100 hp. at 40 rating; motors to be 3 phase, 60 cycle, 222 volt wound rotor with slip rings having a synchronous speed of 900 r.p.m. and loaded capacity speed of 885 r.p.m. Belting to be of endless and high grade double oak tanned leather with a short lap of not less than 12 in. wide. Pulleys to be regulation Rockwood paper pulleys, heavy duty, 2 minute starting drum. Concrete foundations and iron railings required for each motor, bases to be not less than 18 inches in thickness.

Cal., Anaheim—E. B. Merritt, City Clk., will soon award the contract for furnishing a 1350 ft. 12-in. and 300 ft. 4-in. c.i. water pipe; also a deep well pump and motor.

Cal., Inglewood—The city voted $217,000 bonds for the construction of a waterworks system. Plans include the installation of wells, pumps, stand pipe, reservoir and distribution system, or the purchase of pumping plant and distribution system of the Inglewood Water Co. and extending and improving same. Olmsted & Gillelen, 1113 Hollingsworth Bldg., Los Angeles, Engrs. Noted April 1.

P. E. I., North Wiltshire—The Department of Public Works, Ottawa, Ont., will soon award the contract for the construction of a pump house, vocational building, etc., at the Dalton Sanitorium here. R. C. Desrochers, Secy.

Ont., Larder Lake—The Associated Gold Fields Mining Co., Toronto, plans to build a 10,000 hp. hydro-electric power plant here. A. J. Moore, Barnes St., Gouverneur, N. Y., Supt.

CONTRACT AWARDED

Conn., Waterbury—The American Brass Co., Grand and Meadow St., has awarded the contract for the construction of a 1 story power house on Washington Ave., to H. R. Kent Co., 141 Broadway, New York City. Estimated cost, $60,000.

N. Y., Watertown—The Beebes Island Power Corp. will build a new 7000 hp. electric generating plant. Estimated cost, from $30,000 to $50,000. Work will be done by day labor.

Penn., Hershey—The Hershey Chocolate Co. will build a 4,000 hp. power plant. Work will be done by day labor.

Ohio, Cleveland—The Jordan Motor Co., 1010 East 152nd St., has awarded the contract for the construction of a 1 story, 40 x 60 ft. power plant to the Hunkin-Conkey Co., 601 Century Bldg. Estimated cost, $40,000.

Mo., St. Louis—Swift & Co., 866 South Vandeventer St., has awarded the contract for the construction of a 1 story, 50 x 165 ft. boiler house at 746 South Vandeventer St., to the Collins Bros., 536 Rialto Bldg., Kansas City. Estimated cost, $19,000. Noted April 22.

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